GENERAL SCIENCE QUARTERLY

... CONTENTS ...

Page

Objectives as Determining Factors for Making a Course in Junior High School Science. *Zay Barber* 149

The Science of Common Things:

1. What do the Blazing Logs Say? *Joseph R. Lunt* 169
2. A Green Leaf—The Food Factory of the World. *Joseph R. Lunt* 172
3. Heat, the Great Traveler. *Joseph R. Lunt*..... 175
4. The Merry Dance of Electrons. *Joseph R. Lunt* 180

Reckoning and Accounting:

1. Ready Reckoners. *Edna Hood Lissak*.......... 184
2. Without Help of Pen and Ink. *Edna Hood Lissak* 189
3. Tallies, Tellers, and Accounting Machines. *Edna Hood Lissak* 196

Developmental Recitations in General Science. *Walter Kukets* 201

Pennsylvania Teachers Organize 208

Graduate Training 210

The New Books 212

Supplementary Science Sheets for Pupils 218

Science Articles in Current Periodicals 218

What to Make 222

Magazine List 224

Published four times a year: in November, January, March and May
By W. G. WHITMAN, SALEM, MASS.

Entered as second class matter Nov. 6, 1916, at Salem, Mass., under the Act of March 3, 1879

$1.50 a year
40c a copy

MARCH, 1927

VOLUME XI
NUMBER 3

General Science Quarterly

Vol. XI MARCH, 1927 No. 3

Objectives as Determining Factors for Making a Course of Study in Junior High School Science

Zay Barber, University of California.

(Continued from the January number)

VI

Application of Principles

In the actual preparation of a course of study a whole group of people must participate, and the work of trying out the various parts, correcting, eliminating and improving must be a continuing experiment covering a period of years, perhaps even continuing indefinitely as conditions continue to change. This section of the thesis will show in a brief and merely suggestive way, the steps that a course of study committee will need to take in carrying out the ideas concerning course of study making that have been developed in the previous sections.

First, the group must think out, or analyze, the activities of everyday life that demand science knowledge. This means the activities of the ordinary individual, not the man who uses applied science in his vocation. One such activity, for example, is health. There are many activities in which science functions because it is necessary for the proper guidance of the individual in the laws of health. The topics that might be placed in a science course under health science are those concerning the chemistry of food, drink, and air, the physics of heat, light and color, and electricity as it affects the human organism. Then there would be the relation and influence of climate on health. The individual should also know something of the structure and function of the parts of the body, at least enough to understand the processes of digestion, absorption, respiration, circulation, and so on, and the function of the nervous system. He should be acquainted with the elements of danger to which his body as an organism will be exposed, as communicable diseases, and harmful agents for the treatment of disease.

Every citizen uses his knowledge of science in the affairs of his home and community that call for attention from day to day. These include such matters as the water, light, and gas supply, the removal of wastes from the home and premises, telephone service, the building of streets, sidewalks, and highways, as well as railways, bridges, tunnels, etc., the handling of traffic, means of transportation, the work of the health department, the building of public buildings, sanitation and ventilation. The citizen also has a part in various activities that are under the control of the government of his city, state, or nation; such as extermination of insect or animal pests, prevention of fire, preservation of wild plant and animal life and the like.

Many practical activities around the home and garden call for a knowledge of science that may be simple enough in the acquiring and will save the householder from calling in the services of an expert. These include the replacing of electric fuses, repair of wires, small plumbing jobs, upkeep of tools and machines used in the home, garden, or garage. The work about the garden calls for some knowledge of climate, earth science, bacteriology, the habits of insects and animals, and methods of cultivation.

To use all of the mechanical appliances that he comes in contact with does not mean that the individual user must have all of the knowledge that was necessary for the man who invented or made them, but it does mean that he keep adding to his knowledge about the operation and care and maintenance of them.

The width and complexity of the science program should be directed by the width and nature of man's environment. It calls for a balanced amount of all of the sciences and not for specialized technique, but for vision.[17]

Charts or cards might be kept by the committee, on which the various activities are listed under appropriate headings. Then, as each activity is later taken care of in the course of study, it may be checked off the list. The cards would contain only the merest notes on each of the topics to be considered. The following are the kind of lists contemplated:

---

17 Bobbitt, F. K. How to make a curriculum, p. 133.

Health.
Foods, uses and care.
Bacteria, action, prevention, and growth.
Air, pure and impure.
Water, pure and impure. physiological uses, hygienic uses—bathing and laundry.
Heat· humidity of air, effect of climate on health.
Light, artificial and natural, the human eye.
Physiology, respiration and circulation, digestion and absorption, elimination of wastes.
Hygiene, of skin, teeth, air passages, etc.
Exercise and sleep.
Mental hygiene.

Home.
Gardening, soil content, plant food, capillary action, plant structure, plant habits, insect pests, birds.
Household pests, flies, etc.
Sanitation of premises.
Preservation of trees and birds.
Electrical devices.
Automobiles.
Radio.
Musical instruments.
Plumbing, lighting and heating.
Tools and machinery.
Advertised preparations for household use.
Toilet articles, cosmetics, etc.
Patent medicines, drugs, intoxicants.
Safety devices.

Civic Affairs.
Pure water.
Pure milk.
Pure food.
Sewage and garbage disposal.
Highways and streets.
Public buildings, ventilation.
Preventable diseases.
Drainage.
Traffic problems.
Bridges, railways, tunnels.
Fire department.

Intellectual Activities.
The Heavens, solar system, stars, earth's movements.
Evolution, the history of man's development.
Developments in science, inventions and discoveries.
General reading.
Superstitions and fakes.

After making as comprehensive a list of the activities that demand science teaching as they feel is necessary, but before deciding which of all these activities can be made use of in the course in junior high school science, some sort of criteria must be chosen to judge them by. That is, only those should be chosen which will contribute to whatever purposes are set up for science instruction. Obviously the science instruction should contribute as far as possible toward the realizing of the general objectives of all education. Many lists of such objectives have been made and it not necessary to review them here. The most widely accepted has been that made by the National Education Association Commission on the Reorganization of Secondary School Education. They set down the main objectives of secondary education as: (1) Health, (2) Command of the fundamental processes, (3) Worthy home-membership, (4) Vocation, (5) Citizenship, (6) Worthy use of leisure, (7) Ethical character.[18]

Accepting the objectives, a determination must be made as to whether the aims set up for science teaching are aims that will aid in the realizing of the objectives. Thus, using the aims for science teaching given on page 8, a scheme similar to the following would be worked out.

Objectives	*Aims*
Health.............	To train in laws of health and personal hygiene.
Command of fundamental processes.....	To discipline the mind in the scientific method of thinking. To learn to solve simple scientific problems. To learn to generalize. To learn to see things and relations clearly and accurately. To develop easily comprehended scientific theories.
Worthy home-membership.........	To teach how to use the products of science intelligently and economically. To give the scientific knowledge necessary for preparation for life activities. To learn to depend less upon hired specialists in work-a-day science.

18 Cardinal Principles of Secondary Education. Bureau of Education Bulletin, No. 35, 1918, p. 9.

Objectives	*Aims*
	To stamp out superstition and fake.
	To interpret personal life.
Citizenship.........	To understand the achievements of science.
	To interpret the social environment.
	To explain natural phenomena.
	To get an over-view of the field of science.
	To create proper social-civic ideals.
Worthy use of leisure.............	To enjoy pure science.
	To gain the aesthetic, intellectual and moral benefit of science training.
	To lay a foundation for further scientific study.
	To explore the child's interests, aptitudes, and capacities.
	To develop interest in and appreciation of nature.
	To learn to use and enjoy the products of science.
	To encourage recreative interests.
Vocation...........	To give practice in the experimental processes by which scientific principles are discovered and established.
	To gain practical advantage through science.
	To reveal the possibilities in the major fields of science.
	To interpret American industrial life.
	To show the possibilities of being a worker in the field of science.
	To give a mastery of scientific facts useful for later economic-vocational activities.
Ethical character....	To learn through science, order, economy, foresight, efficiency, and the frank facing of facts.
	To train in right habits, and develop desirable ideals, tastes, and appreciations.

Some of the aims seem to fall under more than one of the headings, and the arrangement here is purely a matter of personal judgment. The point is that the aims of science teaching do contribute to the larger objectives set down for all education.

Those are general aims. The next step is for the committee to determine the more immediate and specific aims and list

the activities that can be made use of under each of the special aims. There will be long lists of these special aims and still more numerous will be the activities leading to the fulfillment of each aim. Charts of these aims, objectives and activities may be prepared, showing just how each of the activities finds its place in the scheme. The chart given illustrates this point.

Objectives	*Aims*	*Activities*
Worthy home-membership	To be an efficient member of the home. To co-operate in the care of the home. To understand the mechanics of the household appliances.	Heating and ventilating the home. Sanitation of premises. Extermination of household and garden pests. Preservation of trees and birds. Taking care of animals. Using electrical and mechanical devices. Using and caring for household and garden tools and machinery. Using and caring for musical instruments. Using plumbing, heating and lighting fixtures. Using household chemical products.

The activities listed have been normal adult activities, and it is the purpose of the course of study to show what the pupils can be given as knowledge, and what they can be taught to do, that will bring them to the point where they can effectively carry on these activities. So, for each activity there must be worked out a list of standards of attainment for the pupils.

For the use of the course of study making groups in Berkeley, Mr. H. B. Wilson made social efficiency the aim of all education. For each phase of social efficiency there are necessary outcomes in the form of knowledge to be gained, habits and skills to be developed, and attitudes to be inculcated.

The Oakland Course of Study in science for the Junior High Schools gives under each topic a list of knowledges and skills to be acquired. Ideas from both the Oakland and Berkeley plans have been used in preparing the following chart, in which

the Standards of Attainment for each topic are divided into Knowledge, Skills, and Attitudes. It is not intended that this chart should be complete for the topic suggested. The topics are largely borrowed from the Oakland Course of Study.

STANDARDS OF ATTAINMENT

Activity	*Knowledge*	*Skills*	*Attitudes*
Heating and ventilating home.	To know the elements necessary for burning. To know compounds and elements. To understand kindling temperature. To have a working knowledge of convection currents, oxidation, chemical action, fuel, humidity, gas, liquid, solid condensation, evaporation, expansion. To know damper, flue, grate. To know the danger of carbon monoxide poisoning.	To clean a stove and build a fire. To regulate draughts. To care for the heating plant. To ventilate a room. To use a thermometer. To read a gas meter. To regulate a gas flame.	To desire efficiency, economy, and safety, in the heating and ventilating of the home.

Franklin K. Bobbitt, in his work for the Los Angeles school system, developed the course of study by analyzing activities and selecting certain abilities that were necessary for each activity. His list of abilities is very long, each one being given in detail. One topic, with its corresponding abilities, is given here as suggestive of another method of procedure that might be used.*

* Bobbitt, F. K. How to Make a Curriculum, chaps. 2 and 8.

ACTIVITY:

Health, the maintenance of physical efficiency.

ABILITIES:

Planning of proper diet.
Use of proper methods of ventilation to obtain oxygen.
Understanding of functions of muscles and their care.
Understanding of functions of nervous system in body control and health, both mental and physical. Importance of relaxation.
Understanding of function of sleep and conditions contributing to most effective sleep.
Understanding of micro-organisms and methods of preventing their attack, or caring for their products in case of attack.
Understanding of precautions against spread of disease.
Understanding of dangers from dust, smoke, or gases.
Understanding of factors involved in maintaining proper body temperature.
Knowledge of proper clothing.
Knowledge of proper personal cleanliness.
Knowledge of function and proper care of organs for elimination of wastes from the body.
Knowledge of proper use of sunlight in relation to the body.
Knowledge of how to avoid preventable accidents.
Knowledge of first-aid treatment for common accidents.
Knowledge of proper care of teeth, eyes, ears, throat, skin, hair, scalp, finger-nails, feet.
Knowledge of function and care of heart and blood vessels.
Knowledge of sex functions and their control.
Desire to be well informed on new discoveries concerning health.
Knowledge of home care of sick under physician's direction.
Knowledge of how to maintain proper working conditions.

Instructional units and grading.

After the material to be taught has been selected and the activities and standards of attainment agreed upon, the course of study committee have still before them the task of arranging this material into suitable topics of study, or units under which the topics are to be presented, and determining in what grade each topic shall be taught.

It has been said that the arrangement should be psychological, rather than logical. That is the topics given in each grade should be suited to the psychology of the children in that grade. This matter cannot be arbitrarily settled. Each topic will need to be suited to the needs of the particular group in

which it is to be given, and these needs will depend on the intelligence of the members of the group and to a certain extent on local conditions.

At first the committee may be guided by their knowledge of the interests and capacities of the children in determining how to grade the material. In selecting from the large amount of material available they will be guided by the importance of the subject matter in the lives of the children, both now and in the future; by the use of the material in life situations; and by the difficulty of the topics.

The children's interests and difficulties will be known to experienced teachers by the type of questions that they ask. Knowledge of adolescent psychology is valuable in making the selection of topics and assigning the topics to the grades. In the long run, the suitability and usefulness of certain topics can be determined only after they have been tried in the class room and actual results, successes or failures, observed. For that reason, the first arrangement or grading of the material must be considered as a matter for adjustment: it will be subject to correction and revision. Indeed, the topics selected may prove on trial unsuited for the realizing of the aims set up. So it is only after several committees have worked on a course of study, and revisions and corrections have been made, that it will become a rich and fruitful course of study.

Taking advantage of the child's activities.

In attempting to realize the aims of junior high school science all of the best and most modern practices in instruction should be resorted to, and it is part of the requirement of a good course of study that it should suggest what these practices are and show at what point in the course each may best be used. The child's own interests and abilities should be taken into account, and whenever possible he should be allowed to arrive at the desired outcomes by some sort of project and problem activity that he can direct for himself. Advantage should be taken of all sorts of things that the child normally does and likes to do. This is the idea underlying such science activities as field trips, summer collections, inspection of industrial plants, public works, construction and exhibits, the handling of electrical and mechanical devices at home, use of demonstration material, use of lantern slides and moving pictures,

science clubs, science projects, science assemblies, science bulletin board and question box, reports on interesting articles, and the correlation of science with other school subjects.

Some of the normal and concrete activities that science teaching may make use of are given in the following list:

1. Using things.
2. Seeing things work.
3. Controlling things—care and adjustment.
4. Explaining things.
5. Solving problems that come up in the child's experience.
6. Using out of school activities.
7. Observing scientific things in their natural setting and not at school.
8. Observing in the laboratory to prepare for outside observation or elaborate on phenomena observed outside.
9. Observing by charts and pictures.
10. Learning by reading more about things observed, distant things, past ages, and the history of scientific discoveries.
11. Solving problems that are based on the general principles learned, and involving accurate methods and scientific thinking.
12. Telling about things—learning to express scientific knowledge accurately.
13. Correlating science with other departments of school work.

Further suggestions as to how these activities may be made use of are given in the following pages.

1. *Using things.*

Some of the things that the child uses at home and at school and that may be connected with his science instruction, are the telephone, radio, cooking and heating stoves, lights, phonograph, vacuum cleaner, electric devices, tools, his mechanical toys, skates, bicycle, coaster, water faucets, heating tank for water, flush tank, various applications of the pulley, springs, inclined plane, gears and cogs, and devices using air pressure, as the siphon, medicine dropper, fountain pen, suction caps and non-skid tires. At school, in the laboratory, he learns to use the gas burner, scales, thermometer, barometer, various clamps and holders, and measuring apparatus. Thus, concurrently with his knowledge of underlying principles, is he developing a set of skills that will serve him later. He is finding out that the same natural law may be used in many applications, and he is very likely to try out devices that he has himself

thought of that are variations of what he has seen and worked with at home and in the laboratory.

2. *Seeing things work.*

If there is a scissors' grinder in the neighborhood, if a piece of construction is going on, if the plumber or the electrician, or the telephone "trouble man" is in the house, the children are there also, and eager to see things work. The baby's desire to see the wheels go round continues as long as there are new sorts of wheels to watch. This instinct of the child will keep his mind alert as he begins to learn through his school instruction just what things to watch for and how to explain to his own satisfaction, and the satisfaction of his playmates, what he sees.

This desire of the child makes useful the plan of taking children on excursions to factories where they may see things made; to public works, where they may get first-hand information about the water supply and the lighting systems of the city; and on trips by motor, by rail, and by water, so that they may be familiar with the various means of transportation and ways of developing power.

3. *Controlling things.*

The desire to master and control things is another of the child's interests that may be taken advantage of in the course of science. Each new toy that a child receives presents a new problem in control, and when he has mastered it he is ready for a new toy. In his school work the child may control not only the simple machines and apparatus that he handles, but he may begin to learn how man exercises control over plants and animals. His gardening experiments will show him the way in which man controls plants, by giving them the kind of environment that they need. His observations of his animal pets show him the life habits and functions of the organs of animals. He will learn, by caring for pets, the influence proper diet and cleanliness, and can make generalizations applying to his own life.

4. *Explaining things.*

The child who has done something and has results to report, or who has learned about some special thing to satisfy his

own or his friend's curiosity, willingly and with interest gives his report. This is a very different sort of lesson than is that of the child who has learned in a formal way a set of principles or facts because they happened to be a part of the chapter in the particular book that was in use in his class. Monday morning always brings a fresh supply of things to be explained in the science class, because over the week-end some child has surely seen something or been somewhere that he is anxious to tell about.

5. *Solving problems that come up in the child's experience.*

The child's questions, representing problems that come up in his own experience, have been used by several writers as the basis for a text book in general science. Such questions should have a place in every science program. If the child finds that his questions cannot be satisfactorily answered, then he will feel that his science class is not what he hoped it would be.

Many of the questions that children ask are about the way in which things work, or what makes things happen as they do. But they also bring in results of their own experiments to be explained, and all sorts of questions relating to radio, moving pictures and things that they read about in the daily papers and in the magazines. It is not expected that teachers will be able to answer all of these quesions. The point is to guide the children to the right sources from which they may obtain the answers for themselves, or to show them that in order to answer the question wiser people than they have given years of study.

6. *Using out-of-school activities.*

Outside of school hours, boys and girls have their life of play and work, and it is filled with activities that may be taken advantage of by the science teacher. The Boy Scout and Campfire movements are full of situations of this kind. The boy who is working for a merit badge, or the girl who is working for an honor, is pleased to find that in his science class he can make use of his knowledge of trees and stars and birds, his first-aid and safety-first training, and his gardening and animal raising activities. In turn the science teacher can aid him in his study for honors and give him school credit for such work.

Today many boys and girls have toys that are scientific in nature, such as mechanical sets like "Meccano" and "Erector," electrical outfits, chemical sets, radio sets, weather bureau outfits, surveying sets, microscope sets, experiments with magnetism, light, heat, sound, air, water, and so on. Morris Meister, of Teachers College, Columbia, made an experiment with different groups of pupils to find out the results, educationally, of play with scientific toys. He found that the group that had both teaching and play was superior in all of the tests given to the group that had only teaching, and also that the group that had only directed play was superior to the group that had only teaching.

The manufacturers of these outfits publish magazines, to which many of the boys subscribe. These magazines print the boy's name and address, his picture if they can get it, his letters, and describe new experiments and answer questions. They offer prizes for the best construction and best experiments and give degrees of merit. As Dr. Meister says: "It is hard for adults to appreciate what the International Society of Mecanno Engineers can mean to a boy, or to regard with a boy's mind the Gilbert Institute of Engineering, or the Chemcraft Chemist Club of America. To receive the degree of 'Erector Master Engineer' means quite as much to the boy as the LL.D. or Ph.D. will mean later on,—perhaps more."[19]

7. *Observing scientific things in their natural setting.*

The observing of scientific things in their natural setting and not at school may be done by the children independently, as well as in groups when they are taken on excursions. They will bring in many reports of their own observations, but they should also have directed excursions for the purposeful study of scientific objects or processes. This will include studies of topography, shore life, trips to observatories, zoological gardens, museums, etc., as well as the usual flower and bird trips. Such trips help immeasurably in clarifying the child's ideas, and give the teacher a chance to review and discuss principles taught.

---

19 Meister, Morris. Educational value of scientific toys. General Science Quarterly, vol. 7, p. 167, Mar. 1923.

8. *Observing in the laboratory.*

Laboratory observations leading to some concrete application of a principle outside of school, as experiments on heat to help in the interpretation of the home heating system, the hot water tank, or electrical heating devices, connect up the method of science with its applications. Through such exercises the pupils see how scientists have worked for the proving of laws, and toward the great scientific discoveries and inventions. Through these experiments also the laboratory technique that the pupil will need if he continues his science work, may be developed.

9. *Observing by charts and pictures.*

The place of visual instruction in schools is becoming more and more important. Nowhere in the curriculum is there greater opportunity for presenting material by means of pictures and charts than in science. The children see at the movies countless films showing processes of manufacture, and animals, plants, etc., in their natural setting. The difficulty, in school work, is the expense of getting the slides and films. Mr. J. W. Wilson, formerly head of Visual Instruction for the Detroit schools, has prepared for the United Projector and Film Corporation a set of sixty-four reels organized into a basic course in science.

The projection of ordinary text-book diagrams and pictures on a screen in the class room is especially valuable as an aid in elementary science work.

10. *Learning by reading.*

Among the countless numbers of books on science written for children can be found books on almost every subject studied in the junior high school course. The test books and the courses of study have bibliographies of these and the school libraries are rapidly becoming supplied with the best of them. Boys especially delight in the books that tell them how to do things, books of scientific magic, radio, inventions, and the lives of scientists.

Children pore over the science magazines of the day, such as Popular Science Monthly, Science and Invention, Nature Magazine, Popular Mechanics, The National Geographic, and the various radio, automobile, and outing magazines. This

reading should not be overlooked, and is generally taken advantage of by the science teacher in a weekly discussion period, or in the science club period.

Posting of articles clipped from newspapers and magazines on a bulletin board is an incentive to the children to do research work of this kind, and also offers an opportunity for teaching how to distinguish the true from the false in the material that appears in the newspapers, especially the Sunday supplements.

11. *Solving problems.*

A science problem, something that the child can work out for himself, based on the scientific principles he has learned, and involving accurate methods and scientific thinking, is the best possible test of a child's progress and his grasp of the work he has covered. Such problems may be set by the teacher as a class exercise, or the child may choose his own problem and solve it under the teacher's direction, if he needs aid. This type of work links up with several of the topics already discussed and is of great importance in the method of teaching junior high school science, which it is not the purpose of this paper to discuss.

12. *Telling about things.*

Adolescent children like to display their knowledge and they get a good opportunity in the science class. Discussions in which each child tells about something he has read, or seen, or heard, or done—socialized recitations—are the great clearing house of the science class. Here the teacher can correct misinterpretations, superstitions and wrong concepts, and the children learn to have a scientifically critical view point, and to analyze their experiences in the light of their scientific knowledge. More important still, they realize their inability to explain things, and thus get the value of research and of knowing how to find answers to their own questions. Learning to express things accurately also tends to curb the tendency to "romance" which is sometimes present in adolescents.

13. *Correlation with other departments.*

Correlating science with other departments is really an activity for the entire teaching force rather than for the child. The science department will be able to furnish exhibits for other departments, speakers for club programs, demonstrations for assemblies and the like. In a well organized system teachers of social studies, home economics, manual arts, and science

can work out many topics together and get a great amount of correlation.

Summary.

Charters says in his rules for curriculum making: "Collect the best practices of the race in handling these ideals and activities." This means that the method of teaching a subject must be considered in making a course of study for that subject. It is, therefore, important to have in mind the points in the method of teaching junior high school science that have been noted here. Suggestions similar to these should be incorporated in the course of study in such a manner as to show at what point they may be used most effectively.

Other things the course of study should contain.

To be of greatest use to the teacher is the function of the course of study. Therefore it should contain, in addition to the list of topics to be taught, properly organized and graded, any further suggestions that will simplify the work. The following points should have consideration:

(a) Suggestions concerning special teaching helps that may be used and where they may be obtained. This section of the course of study would contain lists of available charts, slides, films, or models, and lists of books and magazines of special use to teachers.

(b) Lists of books for the use of the pupils, properly classified and graded. It is helpful if such lists are supplemented by the opinion of the members of the course of study committee as to the special usefulness of each book, and the character of the material it contains.

(c) Lists of the materials needed to carry out the work outlined and the sources from which they can be most easily obtained.

Accurately made lists of this kind are immensely useful, especially to new teachers in a system, and the committee should make them as complete as possible.

VII.

Summary.

It has been found, on studying the curricula of the secondary schools of today, that considerable reconstructing is going on. This is necessary because conditions today demand a different sort of curricula from that of the traditional secondary schools. In the effort to make the schools of greatest service to society the six-three-three plan, allowing a three-year junior high

school and a three-year senior high school, has been inaugurated in many places. This means further revision of curricula, and a resulting need for new courses of study.

In the making of new curricula every effort has been made to take account of the individual differences of children and allow for the election of subjects at an earlier age than formerly. Thus the child of junior high school age is aided in discovering his special interests, aptitudes and capacities. The characteristics of the child of adolescent age have also been studied, in order to suit the methods of instruction, and the activities demanded, to the pupil. The junior high school organization allows for the development of situations as nearly as possible like those found in life, and thus trains the pupil in a kind of conduct that he may find useful later on.

Science instruction may be of great use in realizing the aims of the junior high school. There are many phases of the subject and through it most children may discover interests leading either to a hobby or a vocation. The simple sort of science that is advocated for children of this age also brings to them much valuable information about themselves and the world about them. Giving a general view of the field and teaching the children to think and solve their own problems constitutes the greatest contribution of science to junior high school education.

To make a course of study that will embody those phases of science which contribute to the general aims of science instruction and to the aims of the junior high school, will require careful, systematic and intelligent work on the part of the teachers making the course. It demands knowing the needs of the school, knowing the aims of science instruction, and knowing how to find the activities that will aid in realizing these needs and aims. It demands knowing how to organize these activities into a progressive course, with each part graded to the ability of the children. It demands a knowledge of methods suited to the junior high school age. It demands the recognition of individual differences in the intelligence of children.

No one person, nor any one group of people, can hope to make a satisfactory course of study. It is only by making the work a project for several groups, extending over a period of several years, that an approach to an ideal course may be developed. In this study the fundamental material for the carrying out of such a project has been presented.

VII.

CONCLUSION.

It would be possible to write a thesis on objectives as determining factors for constructing a course of study in junior high school science without giving so much basic material, but it is felt that including this material will give a better understanding of the problem to the group for which it is intended.

Section VI could have been made the entire thesis, as the first part is really a study of problems preliminary to it, and all necessary parts of the first sections could have been included as explanatory material in section six.

However, since it would be necessary for a course of study committee to have this background, and since it would have been impossible to write the thesis without having made this preliminary study, the report of it has been made complete, with the idea that if the thesis ever did become useful to a course of study committee, the preliminary study would be essential. If objectives are to be used as determining factors for constructing a course of study in junior high school science, the individuals who are to do the constructing should understand what the nature of these objectives is and the nature of the school in which they are to be used.

Considerable material has been presented which overlaps from one section to another. This is because the effort has been made to make each section complete in itself. There is a vast amount of bibliographical material to go over in getting the information on the nature of the junior high school. The same is true regarding science in the junior high school. Both have had recent rapid development and much has been written on each subject. Therefore the sections bearing on each topic have been made fairly complete in themselves.

In order to work intelligently on the problem of making a course of study for junior high school science, more is needed than simply a knowledge of science, or of how to teach science effectively. A good nature study teacher, or a good teacher of general science or of biology would not necessarily be able to make a satisfactory course of study for junior high school science, if she set out to do it without special study of the factors involved. This thesis has endeavored to show what those factors are, as well as how to use them in making the course of study.

BIBLIOGRAPHY.

Alltucker, Margaret M. Building of the Curriculum. Journal of N. E. A., v. 13, p. 67, Feb. 1924.

Bailey, Edna W. Science in the Junior High School. University High School Journal, v. 1, p. 181, Oct. 1921.

Barr, A. S. Making the Course of Study. Journal of Educational Method, v. 3, p. 371, May, 1924.

Bennett, G. V. The Junior High School. New York, 1919.

Bobbitt F. K. The Curriculum. New York.
How to Make a Curriculum. New York, 1924.

Bonser, F. G. An Elementary School Curriculum. New York, 1922.

Bode, Boyd H. Why Educational Objectives? Journal of Educational Research, v. 10, Oct. 1924.

Briggs, T. H. The Junior High School. Boston, 1920.

Caldwell, Otis W. Functional analysis as the basis for curriculum construction. Journal of Educational Research, v. 10, p. 214, Oct. 1924.
Plan of the American Association for the Advancement of Science to study "The Place of Science in Education." School and Society, v. 20, p. 535, Oct. 1924.

Caldwell, Otis W. Types and principles of curriculum development. School and Society, v. 17, p. 308, Mar. 24, 1923.

Charters, W. W. Curriculum Construction. New York, 1923.

Clement, J. A. Curriculum making in secondary schools. New York, 1923.

Collings, Ellsworth. An Experiment with a Project Curriculum. 1924.

Colvin, S. S. An introduction to high school teaching. New York, 1917.

Cox, P. W. L. Curriculum adjustment in secondary schools. Philadelphia, 1925.

Davis, C. O. Junior high school education. New York, 1924.

Deffenburg, W. S. Specimen junior high school programs of study. U. S. Bureau of Education Bul., 1923, No. 21.

Department of Superintendence of N. E. A. Second Yearbook, Feb. 1924.

Eikenberry, W. L. The teaching of general science. Chicago, 1922.

Glass, J. M. C. Curriculum practices in the junior high and in grades five and six. Supplementary Educational Monographs No. 25, Nov. 1924.

Guthrie, May G. The work of the course of study committee of the Chicago Principals' Club. School and Society, v. 19, p. 132, Feb. 21, 1924.

Hall, G. S. Youth, Its Education, regimen, and hygiene. New York, 1907.

Hines, H. C. Junior high school curricula. New York, 1924.

Inglis, Alexander. Principles of secondary education. New York, 1918.

Johnston, C. H., Newlon, J. H. and Pickell, F. G. Junior-Senior high school administration. New York, 1922.
Judd, C. H. Psychology of high school subjects. Chicago, 1915.
King, Irving. The high school age. New York, 1914.
Koos, L. V. The junior high school. Boston, 1920.
Kyte, G. C. The co-operative development of a course of study. Educational Administration and Supervision, v. 9, p. 517, 1923.
Lull, H. G. and Wilson, H. B. The re-direction of high school instruction. Philadelphia, 1921.
McMurray, Charles. How to organize the curriculum. New York, 1923.
Meister, Morris. The educational value of scientific toys. General Science Quarterly, v. 7, p. 167, Mar. 1923.
Minor, Ruby. Making the course of study. Elementary School Journal, v. 22, p. 655, May, 1922.
Monroe, Paul, and others. Principles of secondary education. New York, 1914.
North Central Association of colleges and secondary schools Bulletin, 1919.
Nutt, H. W. Principles of teaching high school pupils. Boston, 1922.
Pechstein, L. A. and McGregor A. L. Psychology of the junior high school pupil. Boston, 1924.
Report of the Committee for the Reorganization of Science for secondary schools. U. S. Bur. Edu. Bul. 1920, No. 26.
Slosson, Edwin E. Science teaching in a democracy. School and Society, v. 19, p. 383, April 15, 1924.
Snedden, D. Sociological determination of educational objectives. Philadelphia, 1921.
Thomas-Tyndall, E. V. and Myers, J. D. Junior high school life. New York, 1924.
Van Denberg, J. K. The junior high school idea. New York, 1922.
Wells, Margaret A. A project curriculum. New York, 1921.
Willard, E. G. A project in curriculum making. Journal of Educational Method, v. 2, p. 207, Jan. 1923.

COURSES OF STUDY.

Berkeley, California, Public Schools, Course of study monograph, Junior high school science.
Minnesota State Course of Study, General Science.
New York City, Board of Education, Syllabus for Science.
Oakland, California, Superintendent's Bulletin, Course of Study Series No. 21.
Rochester, N. Y. Report on Junior High Schools, Department of Public Instruction.
St. Louis, Mo. Course of study for Ben Blewett Junior High School, in School Review, v. 28, p. 99, Feb. 1920.

The Science of Common Things

JOSEPH R. LUNT

Mechanic Arts High School, Boston, Massachusetts

I. What do the Blazing Logs Say?*

Come, my little friends, let us gather round the fireside this winter's evening. I want you to be warm and comfortable, and I want to see the firelight shining from your bright, smiling faces. Come John, come Mary, pile on another log so that we may watch nature's moving picture unfold—not make believe but real—and listen as she reveals the wonder story of magic changes that mean so much in your lives and mine.

Look—See those waving tongues of yellow flame go roaring up the chimney. Do you know what they are? They are the tongue of a mighty giant, who can help us or destroy us, our best friend or our worst enemy. Watch him. Don't let him escape or he may destroy your home and you with it, even as before he has destroyed thousands of beautiful homes and dear children. And he is a good giant too. He cooks our food and keeps us warm. He runs our factories, our steam engines and ocean liners. He helps make electricity to light our homes, to wash our clothes, and to carry us back and forth to school each day. The blazing log is a gas factory. Gases are driven out of wood by heat, and burn with yellow flames. But listen. Nature is whispering to us another secret. Don't let these gases burn. Keep air away from them. Store them in great tanks. Then you can send them through pipes to your home and mine, so that we may use them in our heaters, gas ranges, and Welsbach mantles.

Bang. There goes a spark. Look out. It's burning the rug. What made that bang? Another mighty giant escaped from his prison. And he is a good giant, too, if you make him behave. Put him in the cylinders of your automobile and he directs his powerful thrust against each piston to make it go. But men have used him for evil purposes—to destroy one another. They have put him into steel tubes—guns and cannon

* Radio Talk to Boys and Girls, Station WEEI, Big Brother Club, Monday, January 25, 1926, 7.00 p. m.

and torpedoes—and trained him to burst forth with sudden violence, and kill and maim. Wood is made of thousands of tiny rooms, or cells, with little pipes between them. At times the pipes become clogged, so that the gases formed by heat, cannot escape. These gases keep pushing harder and harder until they burst forth from their prison walls with a bang, scattering burning pieces of wood, or sparks, in all directions.

What did you say, Marjorie? What is that brown liquid oozing out of the log? Oh, you mean that dirty looking stuff? Don't be deceived. That is only one of Nature's tricks. She often hides beautiful things beneath the surface, for with her, real beauty is more than skin deep. That dirty brown liquid is one of the most wonderful things in the world. It yields powerful explosives to destroy us or soothing medicines to make us well. The chemist, with his magic touch, transforms it into the bright colors of the rainbow, the fragant perfume of the rose, or the sweetness of honey.

Look children. One end of the blazing log has changed from white to black. What is the black stuff? Oh, that is one of nature's greatest elements, the foundation of all living things; trees and flowers and birds and beasts and insects, and even you and I. You see it almost every where. In dust on the window sills, in your coal bin, in the food you eat, in your pencil, gas range, oil heater, automobile, and garden soil. That black substance is carbon—the basis of Dame Nature's strange magic—altered by her to a thousand forms and shapes, from the muck of the swamplands, to great layers of coal hidden for centuries and centuries underground, and even to the precious diamond crystal sparkling with the reflected colors of the rainbow.

And now the yellow flames are gone and we see a pile of red coals, glowing with radiant warmth and cheer, the red coals are lumps of burning carbon. But look closer, my little friends. Do you see those tiny blue flames? Very pretty, you agree. But once more, do not be deceived. Let us look below the surface. Here we have another trick that Dame Nature like to play. She frequently hides bad things under beautiful surfaces to tempt us and to lure us on. Those blue flames are tongues of deadly serpents, just waiting to catch you if you don't watch out. Now you all know that fire needs oxygen to help it burn, and that oxygen is taken from air around us.

When there is plenty of oxygen present to help carbon burn, every tiny particle of carbon simply grabs two tiny particles of oxygen and changes to a harmless, colorless gas, called carbon dioxide. But, what happens when there is not enough oxygen to go around? Why, the same thing that happens when there isn't enough candy to go around? You take only one piece, and you are lucky to get that. So with carbon, when there isn't enough oxygen to go around each tiny particle can grab, not two, but only one particle of oxygen and as a result changes to an entirely different colorless gas, carbon monoxide which is a deadly poison. If this gas burns with its pretty blue flame, there is not danger, for each particle of carbon monoxide may grab a second particle of oxygen and change to harmless carbon dioxide. The real danger comes when the deadly gas escapes unburnt. Tell father, and big brother to open the garage doors when they start the car. When you check the fire in your stove or heater never completely close the smoke pipe dampers. Turn off the burners of the gas range when you go to bed. Watch the deadly serpent, carbon monoxide. Don't let him escape and do you harm.

Br-r-r-r. It is getting chilly. The fire has gone out; only a few black cinders left and a handful of gray ash. But my little friends wait just a moment. The big log piled on the fire has disappeared. Where did it go? Nature touched it with her magic wand and it vanished from sight, borne upward by invisible wings—out the chimney, and into that great surrounding reservoir, the atmosphere. Lost? No. Nature does things for a purpose. That log will come back to quench your thirst and satisfy your hunger. It will give you water and food. Now I can see you smiling at me. But listen, water is made of two gases, hydrogen and oxygen. Wood contains hydrogen, the gas that is sometimes put into toy balloons to make them rise. When wood burns, two tiny particles of hydrogen grab hold of one particle of oxygen in air to make water. Fire is wet. Don't you believe me? Well, you can prove it for yourself. Take a common drinking glass. Be sure it is dry and clean. Now hold the glass upside down. Light a match, and hold the flame just under the mouth of the glass. Watch the inside. Do you see the film of water? Rub your finger over the surface. Wet, isn't it? Tons and tons of water are given off by burning fuels in the same way; from chimneys

of homes and factories, from exhaust pipes of automobiles, from the burners of your gas range, and even from the fuels that burn in your own body.

But how can burning fuel give us food to eat? Oh, that is a longer story—too long for this evening. The next time we sit together before the blazing logs, you may wish to hear another wonder story of how fire gives us good things to eat; apples, and grapes, and bread and sugar and candy. And now, my dear little friends, good night.

II. "A Green Leaf — The Food Factory of the World"*

Come, my little friends, gather round. Have you seen Dame Nature today? What, you haven't seen her, not even in a single one of her changing shapes and forms? Didn't you see her this morning in the orange you ate for breakfast, in delicate frost pictures on the window-pane, in glowing colors of the sunrise, in the crisp chill of winter air, in the white expanse of snow, or in the sleeping buds of maple and elm? LOOK! There she is now, inside your radio set, leading the merry dance of millions of tiniest fairies—the dance of electrons—and now she is hopping right out of your loud speaker and repeating to you every word I say. Get acquainted with nature. Listen to her teachings. Try to understand her laws. For you and I are nature's children. She brought us into the world. She guides our steps along life's pathway and in the end she takes us away. But I'll bet nature tells you lots of secrets she won't tell me. I want your help. Promise to write me a nice letter, so that I can read it to thousands of eager girls and boys. What about? Oh, anything—about the sea shore or mountains, rivers or singing brooks; about blue birds and buttercups and grasshoppers; about the sun and his family and the distant stars; about raindrops and snow crystals and fleecy clouds; about the giant genie, Electricity; about the world of invisible things, yeast and molds, and tiny germs; about the pets or toys you play with; about your home and its many activities; about yourself—anything. Only let it be your own observation or experiment. Something you yourself do, or see with your own eyes.

---

* Radio talk given to boys and girls of the Big Brother Club of Station WEEI, February 1, 1926.

But, my dear friends, I promised to tell you another wonder story this evening. Come close. Do you see that box of geraniums on the window sill? Barbara, bring it here please. Now break off a single green leaf. Tell me what you see. Only a thin blade with scalloped edges and veins running through it? Tear the leaf apart. Tell me what you see inside. Only a spongy mass of green stuff? And you claim to have sharp eyes? I am afraid they are blind to the real truth and beauty of life. The unaided eye is poor. It never shows us things as they really are—only a jumbled mass, like trees on a distant mountain. Look here. Do you see this brass tube with pieces of glass at either end. What does it do? Why, it makes things look hundreds of times bigger than they actually are. It magnifies things. It shows you the secrets of the invisible world. Give me that sharp knife. I'll cut off a thin slice of the leaf, like a slice of bread, and put it under the brass tube. Now take a look at the inside of a leaf. Wonderful, you say. See the thousands of little cells, square ones and round ones, all packed together like cells of a honey comb. See, they are filled with an amber fluid—life fluid—protoplasm, the living stuff that fills the animal cells—the cells that make up your body and mine. Do you see that round kernel in the center of each cell—the nucleus? That tiny object is the director of growth. In your body it helps to build new cells to make you bigger and stronger. Look through the brass tube again. Do you see those beautiful green balls, glistening like emeralds. They are chloroplasts, the objects that make leaves green. Green paint? Oh no, leaves are not painted. The green color is inside and not on the surface. Here, give me that geranium leaf again. Look at the under side. What, you only see skin with a few hairs on it. Let me peel off a piece of the skin and put it under the brass tube. Don't crowd. Stand back James. Give Rita a chance. Why. We see hundreds of little mouths with lips, just like ours. Some are open and others are closed. That's right! Didn't you know that leaves have mouths that open and shut. There are thousands and thousands of these tiny mouths, or stomata, on the surface of every leaf and they are just as important as your own mouths.

But I promised to tell you about the work of leaves. They

are the food-makers of the world. Without them we would soon starve. They give us sugar and starch, apples and oranges, beans and potatoes, bread and cereals,—wheat, corn, oats, rice and rye. And even more. For these foods are eaten by animals and changed into milk, butter, eggs, beef steak and chops. The green leaf is a factory, the multitude of tiny cells are rooms and the emerald green balls are machines. Power is furnished by millions of bright rays of sunlight. What did you say? Where do leaves get the raw materials to make all these things? Dame Nature is a wonderful cook. Look on her pantry shelf. About the only things you will find are three big bottles. One bottle is filled with a light colorless gas, hydrogen. The second bottle contains another invisible gas, oxygen. The third bottle is filled with black soot, carbon. She simply mixes these common elements in different proportions, unites them with her magic touch—and, presto, you have sugar, starch, and all the other things I mentioned. Sounds like a fairy story? Perhaps it does, but this one is true. Let me prove it by a simple experiment. Put this lump of sugar into an old tablespoon and hold it over a gas flame until the sugar starts to burn. Now take a clean, dry, drinking glass. Hold it upside down just above the flame. Watch the inside of the glass. See the drops of water. Now look in the spoon. See the black stuff. Carbon, isn't it? We have taken a lump of sugar apart. All we get is clear water and black carbon. If we had time we could easily separate water into its parts. We could break it up and show that it is made of the two common, invisible gases, hydrogen and oxygen. If your curiosity is aroused you can go further. You can break up a lump of starch or any of the other foods mentioned. You will discover the same three basic elements, hydrogen, oxygen and carbon.

Water and carbon,—they are about the only raw materials needed by this marvelous factory, the green leaf. Water comes from the soil. It is absorbed by numerous root fibres of the plant, flows up through long narrow pipes in the stem and out through the network of delicate veins to all parts of the leaf. Carbon comes from the air. What? You don't see any solid lumps of black carbon in the air. No. The carbon has been changed to another form—from a black solid to an invisible gas

—carbon dioxide. This gas passes into the leaf cells from the air through the thousands of tiny mouths. And now, with all the necessary raw materials supplied, Dame Nature is ready to start work. She may take six teaspoonsful of carbon, ten teaspoonsful of hydrogen and five teaspoonsful of oxygen, mix them together, put them into one of the machines, turn on the sunlight—and—behold--out cames a tiny lump of starch. Or, if she desires, she may take six teaspoonsful of black soot, twelve teaspoonsful of hydrogen and six teaspoonsful of oxygen —and out comes a tiny lump of sugar. And so it goes. Dame Nature simply combines the three elements in varying proportions to make lots of good things for you and me to eat. But I have left the best part of my story. Inhale! You breathe in life giving oxygen. Exhale. You breathe out suffocating carbon dioxide. Light a candle. Oxygen makes it burn brightly. Bring the mouth of a jar down over the burning candle. The flame soon uses up the oxygen and then goes out. It is suffocated by carbon dioxide. Everyday, tons and tons of carbon dioxide are given off into the air from fires and lungs of animals, and many tons of oxygen are used up. But why don't we all die? And what keeps the fires burning in our stoves and heaters? This green leaf takes care of that. It takes suffocating carbon dioxide out of the air and puts back life-giving oxygen. Thus does nature, in this wonderful cycle, accomplish a double purpose. She gives us good food to eat and pure air to breathe.

Oh, I wish I had more time to tell you about all the other marvelous things a green leaf does—how it moves and breathes, and sleeps, and how it digests things, and makes rain—and how it changes from the soft tints of spring time to the vivid colors of autumn, but I must stop now. Good night.

III. Heat, The Great Traveler*

Good evening, fellow scientists of Big Brother Club. Thank you for all the interesting letters you wrote. I shall try to answer them as soon as possible. Now get your pencil and paper pad ready. During the past week I have received many re-

* Talk given at the Big Brother Club period of WEEI, on Feb. 8, 1926.

quests from both science teachers and pupils to conduct a radio science lesson. Will you join my class? Next Monday evening we will have a real lesson in science. I'll do the experiments right here before the microphone, and I want you to follow me, and do the same experiments at home. Now you must be ready to start. Have everything ready. Place a small table near your radio set. Put the following articles on the table. Come now, write them down, so you won't forget: A drinking glass, two white saucers, two short candles, a box of matches and a common pin. Have one saucer half full of cold water. Be sure the wicks of the candles are fairly long, so you can light them quickly. Don't forget. Be ready to start promptly next Monday evening, at 7.00 o'clock. Gather round, my young friends, and listen. I am going to tell you another wonder story this evening. It's about *Heat, The Great Traveler.*

Heat is a queer chap. You can't see him. He doesn't make any noise. But you can feel his presence. Rub your hands together fast. Feel him? Light a match. Feel him? Pull up the shade and let in the sunshine. Feel him? Plug your electric iron into a socket and snap the switch. Feel him again? Another strange thing. You have to keep this queer chap, Heat, at just the right distance. Let him come too close and he burns you or makes you perspire. If on the other hand you let him go too far away he makes you shiver with cold. Heat is Dame Nature's messenger. She sends him on all kinds of errands, to warm our houses in winter, to melt the snow and ice in spring, and to make plants grow in summer. He is always going somewhere. At times he barely crawls, a few inches a minute—again he jumps into his roadster and goes sixty miles an hour—at other times he cranks up his flying machine and travels to the moon in a couple of seconds.

Heat travels in three ways: by conduction, convection, and radiation. Hold one end of an iron rod in the fire. Heat travels slowly along the rod to your hand by conduction. But how? Well, the rod is made up of countless millions of tiny particles of iron,—so small that they are invisible. Not only iron, but every material thing, solids, liquids, and gases, is made up of its own kind of tiny particles, molecules, we call them. And these molecules love to dance. They are always dancing to the tune of heat. Quicken the heat and they dance

faster. Slow down the heat and they change time from a quick foxtrot to a slower waltz. And these excitable little fellows have rather bad manners. They push and shove and bump into one another without regard. In your iron rod, heat from the fire first starts the dance of tiny molecules at one end—these bump against their neighbors and start them dancing and this action is repeated until the whole rod is hot. But different kinds of molecules are like different boys and girls. Some like to dance better than others. They need less coaxing. Try this simple experiment. Put three teaspoons in half a glass of hot water; a silver spoon, an aluminum spoon, and an iron spoon. Feel of the end of each spoon at short intervals. Notice the difference. Remarkable, isn't it? Heat travels through the silver spoon very quickly—a little slower through the aluminum spoon, and still slower through the iron spoon. You have proved that some substances conduct heat faster than others. Now metals are good conductors. Heat travels through them quickly. That's why your kettles are made of aluminum and your radiators of iron. Air conducts heat slowly. That's why furs and woolen coats keep you warm in winter. The heat of your body is held in by many air spaces between the hairs or loosely woven fibres. You know what a thermos bottle is. It keeps hot things hot and cold things cold, by means of a double glass wall with a vacuum between. Very little heat can pass through a vacuum by conduction because most of the molecules have been removed. Perhaps your mother cooks with stored heat. She puts the roast in the oven of her gas or electric range, turns on the heat for a few minutes and then shuts it off. Heat stored in the oven stays there and completes the cooking of the roast, and your monthly bill for gas or electricity is much lower.

In the second method, convection, Dame Nature sends her messenger heat in moving currents of warm air or water, in great ocean currents, like the gulf stream or in balmy south winds, to carry warmth and comfort to cold northern lands. In your own house he leaps out of the register or runs through the radiator to keep you warm. Air or water expand when heated. A gallon of cold water is heavier than a gallon of warm water and a gallon of cold air is heavier than a gallon of warm air.

When cold air enters your furnace, it is heated, expands, and rises through pipes to each room. The rising warm air is simply pushed up by the heavier cold air underneath. The same things are true of hot water heating.

And now we come to the third method—the most marvelous of all, where Dame Nature's messenger, heat, jumps into his flying machine and shoots through space, 186,000 miles a second. How do you suppose we get heat from the sun? Doesn't it seem to come in straight rays and doesn't it pass right through the window pane? Sit before an open fire-place. Feel the heat on your face? It comes straight at you, doesn't it? Is it warm air you feel? No. The warm air is going up the chimney. Can the heat travel to your face by conduction? No. Air is a poor conductor. Then, there must be another method—and because the heat seems to travel in rays—we call it *radiation.* Have you ever opened the furnace door when the fire is red hot? Doesn't the heat come straight at you, and doesn't it travel quickly? Hold a piece of glass before your face. Heat comes right through the glass. Hold a book in front of your face and you can't feel the heat. The book stops it. When these heat rays strike a transparent substance they usually go right through, but whenever they strike anything like a book, or a piece of cloth, they are stopped, and absorbed, somewhat as a sponge absorbs water.

Say, do you know, dark colors absorb heat rays faster than light colors? Try this simple experiment. Take two shiny tin cans, coffee cans or crisco cans will do. Cover one can completely with black soot from a candle flame. Fill each can with ice cold water. Set them on the window sill when the sun is shining. After an hour or two feel the water in each can. The water in the black can is much warmer than the water in the shiny one. This explains why water heats more quickly in a black kettle than it does in a shiny kettle. It also explains why a black suit feels warmer in summer than a light colored one. But there is another side to this story. Dark colors give off heat rays faster than light colors. Take the same two cans again, the black one and the shiny one. Fill them with boiling hot water and set them on

the table for about ten minutes. Feel the water in each can. The water in the black can cools much quicker, doesn't it? This explains why water stays hot longer in a shiny kettle than it does in a black one. Look at your own radiators. Are they shiny or black? You get more heat from a black radiator. Which is warmer in winter, a dark suit or a light suit? A light suit, isn't it? A black suit allows the heat of the body to escape faster. Why do you suppose so many animals of the arctic regions have white fur? White fur helps them to keep warm.

Let me ask you this question. Does "hot" and "heat" mean the same thing? No. Anything can be red hot and not have much heat, or anything can have lots of heat and not be hot. A spoonful of boiling water is much hotter than a bath tub filled with lukewarm water. But the bath-tub full of lukewarm water contains more heat, much more. A red hot pin may be just as hot as a red-hot flatiron—but you know that it takes longer to heat the flatiron and that it stays hot longer. In other words, the flatiron has more heat than the pin. Even at the same temperature equal weights of different substances hold different amounts of heat. For example, a pound of water at 100 degrees contains ten times as much heat as a pound of iron at the same temperature. A thermometer tells how hot anything is—but it doesn't tell you how much heat it contains. Heat is measured by a metal cylinder—in calories —not in degrees.

And now, my friends, listen. Do you know where heat, the great traveler fits into nature's wonder scheme? Dame Nature takes these radio waves that now carry the sound of my voice to your ears—she reduces them in length—and behold. You have heat. She reduces the length a little more and you have light. She makes the waves shorter and you have a picture— she reduces the length still more and enables you to look right through the human body. Radio, heat, light, photography and X-rays are all linked together into one miracle chain—the miracle chain that Dame Nature wears—and who knows how long that chain maybe—or how many golden links it may contain? Good night.

IV. The Merry Dance of Electrons*

To my radio Science class:—Don't miss the experiments next Monday night. You will have lots of fun. Be sure to have the following articles ready: Two toy rubber balloons; two pieces of string, about 2 feet long: a piece of fur, fairly large—a fur scarf, neckpiece or fur coat. Note—The fur will not be injured in any way. If you can't get the fur, you may use a woolen sweater.

Have the balloons all ready before the experiment starts. First blow them up, not too full. Tie the balloons with pieces of string and hang them up about level with your face, and about 1 foot apart. Let each balloon hang from one end of the string, and have the string 3 feet long. Do not hang the balloons near the walls or sides of the room. For a support you can stretch a piece of strong twine across the room about 8 feet high, and hang the balloons from the center of this. Let them hang down about 3 feet.

[The above directions were given the previous week.]

Good evening boys and girls. Here we are again, with more experiments for our radio Science class. But first let me read a few letters. (Reads letters.)

During my last lesson I told you about Dame Nature's mixing bowl. I told you how she takes a few particles, or atoms, of carbon, hydrogen and oxygen, mixes them in her bowl, combines them, and gives you wood alcohol, vinegar, formaldehyde, ether, carbolic acid or vanilla extract—how she simply adds 3 particles of oxygen, 3 particles of carbon and 6 particles of hydrogen to sour milk and gives you honey to spread on your bread. Or how she simply takes 2 particles of hydrogen and 1 particle of oxygen away from your honey, and behold your glass of honey is transformed into a sheet of writing paper or a stick of wood. All this wonderful story had to do with tiny atoms. But tonight I am going to let you break an atom apart and find the tiniest things in all the world,—electrons. Yes, sir. My story tonight is about electrons—THE MERRY DANCE OF ELECTRONS.

Are you ready for the experiments? You have two toy balloons and a piece of fur. And did you blow up the balloons and suspend them by pieces of string according to instructions? I have Big Brother's Studio all rigged up. I stretched a piece of twine across the studio, about 8 feet high. I have two balloons, pretty ones, all blown up, and each tied to the ends of a piece of string about 2 or 3 feet long. Then I suspended the

---

* Radio Science lesson given at Big Brother Club of Station WEEI, February 7, 1927.

two balloons, hung them up, about a foot apart, and about 3 feet from the floor. Oh, yes, and I have an old fur scarf, one I borrowed from my wife. All ready! Let's start! Let's play with one balloon first. Rub the balloon with your piece of fur. Wrap the fur around the balloon and rub briskly. Now step back. Bring the fur near the balloons. See! The balloon is attracted. It follows the fur. Try again. Rub the balloon with the fur, rub on both sides at the same time, fast and vigorously. Now, hold your nose near the balloon. Ah! Surprised? The balloon jumps up and hits you in the nose, and say, did you feel that spark? I'll bet you did. And heard it too. Try again. Let the balloon hit your nose. Isn't that a good one? All ready! Rub the balloon with the fur, *vigorously*. Stoop over. Hold the top of your head near the balloon The balloon jumps up, as though alive, and hits your hair—and stays there—and can you feel your hair stand up straight? You probably have more hair than I have. But I can feel my few remaining hairs stand up when the balloon hits my head. Let us try a new one. First rub one balloon with the fur. Now rub the second balloon, fast and vigorously. Now stand away. Isn't that pretty? See? The balloons fly apart—repel each other. See! They stand right out—apparently there is some ill feeling between them. The balloons dislike one other. They seem to be enemies. Let us see if we can make them friends. Just hold one hand between the two balloons, right in the middle. Isn't that interesting? The two balloons, come together, they kiss and make up. They are friends again. Try this one. Rub both balloons with the fur. Now hold your head between them. See? They come together, hit the sides of your head, and cling there. You have two ear rings. And I'll bet you felt the spark. Didn't you?

Tell me now. What is all this about? And why do the toy balloons jump around so strangely? Let me say, first of all, that you produce electricity when you rub the balloons with the fur. You produce electricity by rubbing, or friction. Where does the electricity come from? Oh, everything contains electricity. Your hair, hat, shoes, dress, coat, pencil, ruler, everything. Yes, sir! There is enough electricity in a pair of old shoes, to light your home, or run your radio set, or to make your vacuum cleaner go—plenty—if you could only set it free and collect it. Collect it I said, for we cannot make electricity.

It already exists, is present, in every material thing. All we can do is to set it free and collect it.

But what is this electricity you set free when you rub balloons with a piece of fur. You simply rub countless tiny electrons off the fur on to the balloons, and electrons are nothing more or less than minute charges of electricity—negative electricity. The fur then loses electrons and the rubber balloons gain electrons. Therefore, we say there are two kinds of electricity, positive and negative. Any object that gets more than its usual share of electrons, we say has a negative charge of electricity. Any object that loses electrons or contains less than its usual share, we say has a positive charge of electricity. Any object that has its usual number of electrons, neither gains nor loses, we call neutral—or unelectrified. And this explanation accounts for the strange behavior of the balloons, for negative electricity repels negative electricity, positive repels positive, but positive and negative electricity always attract each other. You rubbed electrons off the fur on to the balloons. Therefore, the fur lost electrons and was charged with positive electricity while the balloons gained electrons and became charged with negative electricity. In the same way, the balloons received more electrons than your body contains—so that your own body was positive as compared to the electric charges on the rubber balloons. And so the fur attracted the balloon, your hand attracted the balloon, your hair attracted the balloon, your chin attracted the balloon, your nose attracted the balloon because positive and negative electricity always attract each other. On the other hand, when you rubbed both balloons, each one received an excess of electrons, a negative charge, and so repelled, pushed each other away. Two objects charged with negative electricity always repel each other. I have told you why the rubber balloons acted so strangely. But, tell me: What are electrons? Where do they come from? What do they do? This is a wonderful story. It covers the whole subject of electricity—a subject far too long for one evening's lesson. Let me tell you only a few facts about the identity and behavior of these tiny negative particles of electricity. All matter is made up of molecules and all molecules of atoms. But examine an atom and what do you find? You find a whole family with Mrs. Nucleus, Mother Nucleus at the center, and dancing around her, her children, *baby electrons*. Consider the drop

of water again. It is made up of millions of particles of water, molecules. Examine one particle: one molecule of water. What do you find? Two tiny specks, two atoms of hydrogen, and one tiny speck or atom of oxygen. Now let us study the atoms. We find two families: Mrs. Hydrogen Nucleus with one child, one baby electron prancing around her, and Mrs. Oxygen Nucleus with 8 children, with 8 baby electrons in her family circle. Now, just pull the electrons away from the families, to which they belong, collect them by batteries, or generators, and you have electricity. Billions of electrons are collected every second by high generators at central power stations and sent along wires to your home. They stream into your lamp filaments to make them glow; they flow through the coils of your flatiron, or electric range to give you heat; they pass into the windings of the motor that operates your vacuum cleaner or washing machine.

When you talk into your telephone transmitter, a thin piece of metal vibrates, pressing with varying intensity against lumps of roasted coal, and starting a merry dance of electrons along the wires, so that, when your friend at the other end of the line picks up her receiver, she hears your words, spoken distinctly, because the same electron dance, started by the transmitter is repeated around the coils of a magnet, varying its strength and making a second thin piece of metal vibrate in unison with the first one. Time will not permit me tonight to give you further explanations of the strange behavior of these tiniest particles of electricity. Perhaps you would like to know more about the merry dance of electrons, how they reproduce the words I am speaking into this microphone, how they enable us to transmit actual pictures by wireless, or enable us to look right through the human body. Good night.

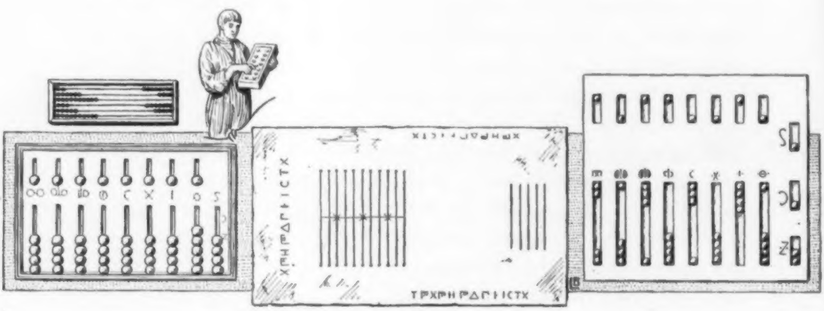
Reckoning and Accounting*

By Edna Hook Lissak.

(Illustrations by Edna Hood Lissak)

I. Ready Reckoners

The sons of Noah used Ready Reckoners to "aid their memory" in keeping count among themselves of the increase of their flocks. Their calculating machines were pebbles, shells, kernels of grain, beans or nuts. The sons of Noah of a later generation still depend upon their ready reckoners, but the pebbles and kernels have become intricate mechanisms which add, subtract, divide or multiply, and solve all the problems of the modern business world. Between the pebbles of the post-flood era and the cash registers and computing machines of today lies the whole story of mathematics and the dependence of the people upon mechanical devices to aid them in their arithmetic.



The Abacus as used by the Greeks and Romans.

The small flat stones of the Greeks, rounded and polished for counters, no doubt suggested the metalones of the middle ages. The Greek term for them gives us "ciphering," while the Roman equivalent, "calculi," christens our calculating machine. Sometimes the Greek stones represented a large number, sometimes a small one. Solon, about 600 B. C., compares the different grades of society to the varying and arbitrary values of the counters on the line.

* From "Edison Monthly," by courtesy of New York Edison Company.

The calculation was made on a sanded floor or table upon which parallel lines were marked with a stylus. On this first abacus the Greek youth was also taught to write. Later, the abacus passed to the Romans, and the counters were run in grooves or strung on wires. In the latter form it reached the Orient, was carried by the invading Mongols into Russia in the thirteenth century, and also found its way to Persia. It reached America via the Chinese laundry. In all these countries and among their natives wherever they may be, the abacus, in different forms, but the same in principle, is still in use.

In the Chinese abacus the unit is any ball in the larger compartment placed against the bar; these increase decimally. The corresponding balls in the smaller compartment increase by fives.

A marble slab, found in the ancient Greek island of Salamis, is supposed to have been a Greek abacus or counting-table of the type used by bankers. The calculator sat at one of the long sides and used his jetons in the different spaces separated by the incised lines. Small bands at the right were for fractions. The characters represent the numbers.

An ancient Roman abacus, said to have been used in Rome and in China, is still used in France to teach children to count. It was formerly used for the same purpose in England. It was brought to France by one of Napoleon's generals, the geometrician Ponselet, who learned its use while a captive in Russia.

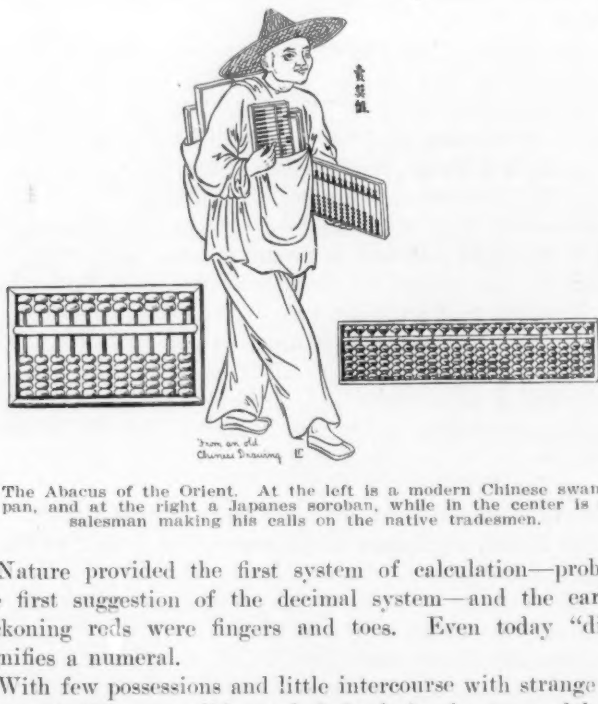
In another Roman abacus for addition and subtraction, the numbers represented by the pins in each groove are marked on it; the longer ones at the bottom are for units; the shorter, at the top, for decimals.

In the words of a student of ancient Chinese history, "The Ho-Ho Twins, or Spirits of Harmony, are famed as the inventors of the abacus. It is said that when they realized the perfection of their invention, they laughed so immoderately that their deaths ensued as a result. They are to be found in every temple and are worshipped by all the Chinese people."

Writing in 1735, the French Jesuit and geographer, Du Halde, tells how the verification of an astronomical semicircle previously constructed by Father Verbiest, was worked out far more rapidly by the Emperor on his "swanpan" than by the missionary calculating with Arabic figures.

At a much earlier period, reckoning rods had been used in China. The first known reference to them, apparently as an innovation, is in the proclamation of a ruler of the fourth century B. C. In offering high reward to gifted men of other states, he vehemently declares against good mathematicians using "counting stalks" in their calculations.

As proof of the great wealth of a court official of the fourth century A. D., we read that "when he took his ivory tallies in hand" to compute his income, "he spent his nights in calculating and could not stop." A later emperor had rods cast in iron for the use of the common people, while the Koreans still calculate with bamboo rods and with small stones and coins.

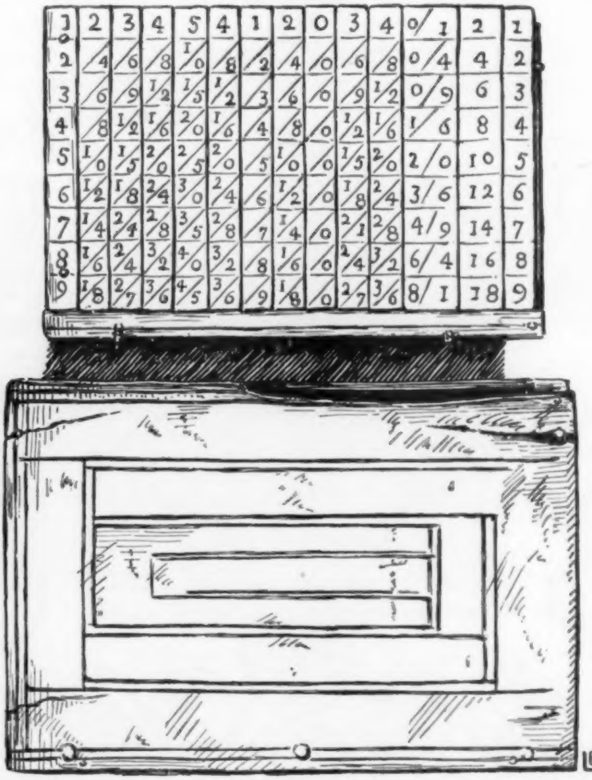


The Abacus of the Orient. At the left is a modern Chinese swan-pan, and at the right a Japanes soroban, while in the center is a salesman making his calls on the native tradesmen.

Nature provided the first system of calculation—probably the first suggestion of the decimal system—and the earliest reckoning rods were fingers and toes. Even today "digit" signifies a numeral.

With few possessions and little intercourse with strange peoples, primitive man did not feel the lack of a more elaborate system of notation, and only when the need became imperative for a more permanent method of expressing two sums at a time, were the pebbles brought into service.

There are still tribes to whom "one hand" means five, and "two hands" ten. In the Persian language the same word means "hand" and "five." The Muysca Indians of South America express eleven, twelve, etc., by "foot one," "foot two," and so on.



A set of "Neper's Bones," in the British Museum. This calculating device, developed more than three hundred years ago, was one of the first machines for solving problems in arithmetic. The methods of using it were described in Napier's "Rabdologiæ," printed in 1617.

The eleventh century saw the Arabic numerals and the decimal system introduced into Europe. This ended the use of the cumbersome Greek and Roman numerals for calculation; mathematical operations were simplified, and the way opened for the development of modern machines.

What might be classed as the first of these was the invention of John Napier, the famous creator of Logarithms and of the now indispensable decimal point. He was Jhone Neper or Jhone Nepair in his own day, and his "numbering rods"

These drawings of Jetons or Counters, are taken from the book of an English authority on coins and medals, published in 1769, when they were still in use. Although they are from different countries and times, they were probably all made in Nuremberg. The central drawing is from a tapestry of the "jeton" period.

were familiarly known as "Neper's Bones." They were invented in 1617—the year of his death—and were popular both in England and abroad even in the early nineteenth century.

Opinions vary as to their value in doing away with the 'tediousness of calculations,"—the inventor's avowed reason for devising them.

The rods were kept in a flat, square box as wide as ten rods and thick enough to hold six. When the rods are put in the box, the top number is shown beyond the box—and on one of the flat sides the index-rod is fixed at the edge—while the small ledge at the bottom supports the rods while in use. Some of the rods were made with four different faces and figures on each for different purposes.

Professor R. A. Sampson, of the University of Edinburgh, Astronomer Royal for Scotland, writing of the Napier Tercentenary Celebration of July, 1914, calls the method a very practical one, which probably saved many errors as well as the tedium attached to heavy multiplications; but Glaisher's remark may be quoted, that "nothing shows more clearly the rude state of arithmetical knowledge at the beginning of the seventeenth century than the universal satisfaction with which this invention was welcomed by all classes."

There can be but one opinion, however, as to the popularity and length of service of the counter. From the earliest crude form—the pebble—to the ornate brass and copper jeton of the French and English kings and of the Exchequer of England, into the eighteenth century, it has been the most constantly used "arithmeticke machine," and the French motto is still of value, "Beware of mistakes; who reckons well will get results."

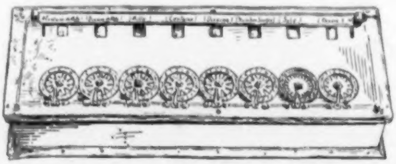
II. Without the Help of Pen and Ink

From the simple abacus, with its varied adaptations, as previously described, it was a long step forward to the first automatic calculator which appeared near the middle of the seventeenth century. Its inventor, Blaise Pascal, at the age of fifteen was a mathematician of note. When the young man's father was appointed Governor Superintendent of Haute Normandie by Richelieu, the lad, because of his ability, was called upon to verify the complex accounts of a great province. "Deniers," "sols," and "livres" had to be counted—12 deniers made one sol, and 20 sols one livre—and for this the use of jetons was not practical. So he undertook to develop a machine to aid him in his computations, and in 1642, at the age of

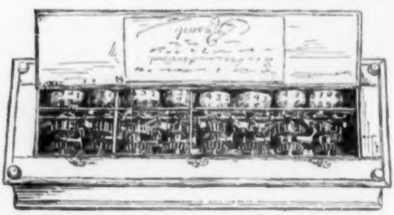
nineteen, succeeded in devising the first automatic calculating machine.

In order to obtain from the king the privilege of manufacturing his machine—which in those days was similar to securing patent rights—he presented a model—the only one he is known to have made himself, and on which he spared no pains—to the Grand Chancellor Segnier. Its machinery was contained in a box of rosewood and brass with bands of copper, and was no larger than a glove box. In 1649 he was given the desired permission.

Pascal spent about ten years in trying to develop and introduce a reliable machine that would be easily portable and



The first calculating machine was invented by Blaise Pascal in the middle of the 17th century. The inventor was only seventeen. Although it dealt with the intricacies of French currency it was no larger than a glove box.

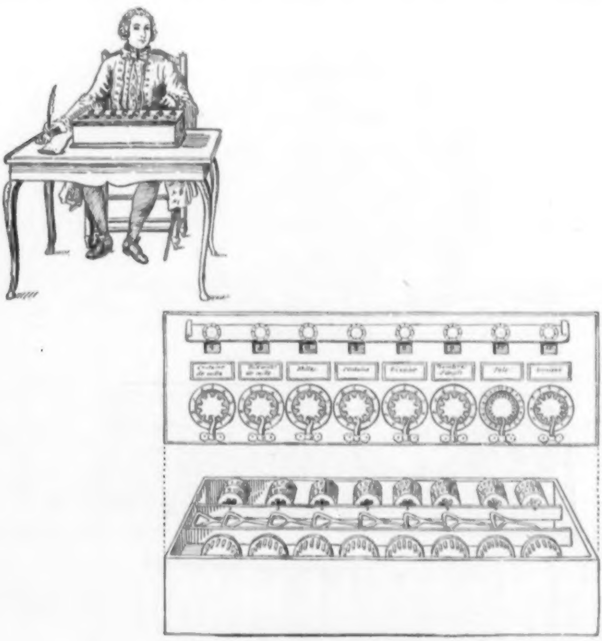


The mechanism of the Pascal machine and an inscription on the lid bearing his name.

simple to learn to operate. With the aid of an ordinary locksmith about fifty models were made, and many materials—ivory, wood, iron and copper—were variously combined in them. Efforts were made to interest influential people in them, and one model was sent to Queen Christine of Sweden.

Although the first type of machine which he invented was approved by the French Academy, whose scientists called it admirable, Pascal was never satisfied with it, and until almost

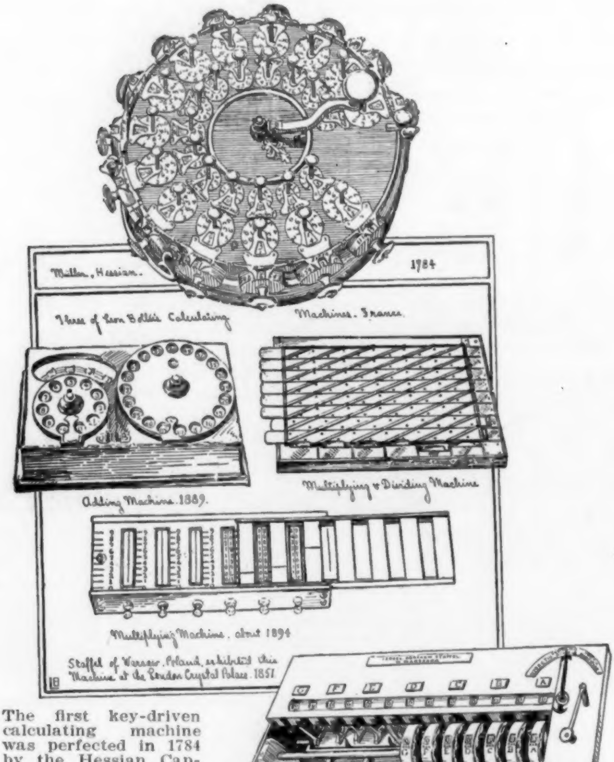
the end of his life he continued to work on it, hoping to evolve a machine that would extract square roots and perform various operations with fractions.



Old French Academy drawings of early Calculating Machines, published in 1735. On the lid of the box containing the machinery was a movable frame which discloses either of two sets of figures when moved up or down. The gentleman at the top is operating a style, called a "director."

L'Epine in 1725 and Boitissendeau in 1730 improved upon Pascal's machine, but before that, in 1671, Leibnitz had conceived the idea of adapting the principle applied in this invention for simple addition to a mechanism capable of performing multiplication by means of rapid successive additions, and in 1673 presented his plan to the Royal Society of London. He had two machines built in 1694 and 1706, but although he spent about 100,000 francs on them, they were poorly made and faulty in execution,—due to the fact that the workmen were unable to grasp his ideas and the machine tools of that time were not accurate.

Prior to this in England Sir Samuel Morland, master of mechanics to Charles II, in a letter dated May 13, 1666, refers to two "Arithmetical Machines" he had invented—one for addition and subtraction, and the other for multiplication,



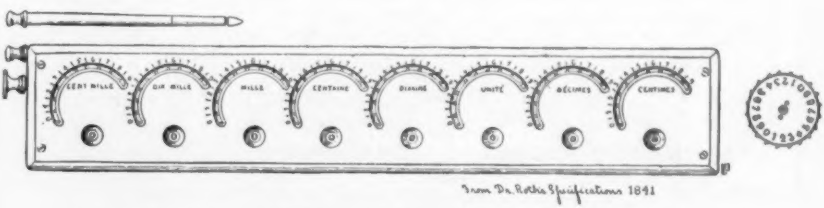
The first key-driven calculating machine was perfected in 1784 by the Hessian Captain of Engineers Müller. A model of his machine is shown at the top. A collection of three types of calculating machines of the youthful French inventor, Léon Bollée, appear in the center. The model below was designed by Staffel, a resident of Warsaw.

division, and the extraction of the square, cube, and even fourth roots. Owing to "the importunity of his very good friends," he printed a description of them in 1673, in which he suggested that if any "curious person" cared to go to the

expense of combining the two machines, all the four operations of arithmetic could then be performed "Without the help of Pen and Ink."

To free man's head and hands by the mechanical performance of mathematical operations was the aim of the inventors in machines devised by Doctor Hook in about 1670; by Leupold in 1727 (an adaptation of Napier's Rods); by the German pastor Hahn in 1774 and 1777; and by the two Poles, Abraham Stern, clockmaker, in 1814, and Staffel, who formerly had been a watchmaker's apprentice, in 1845. Also there were many others at about this time.

The first key-driven machine was that of the Hessian Captain of Engineers, Müller, in 1784. This principle was applied to other early machines, but did not take practical form until its nineteenth century development in America, where,

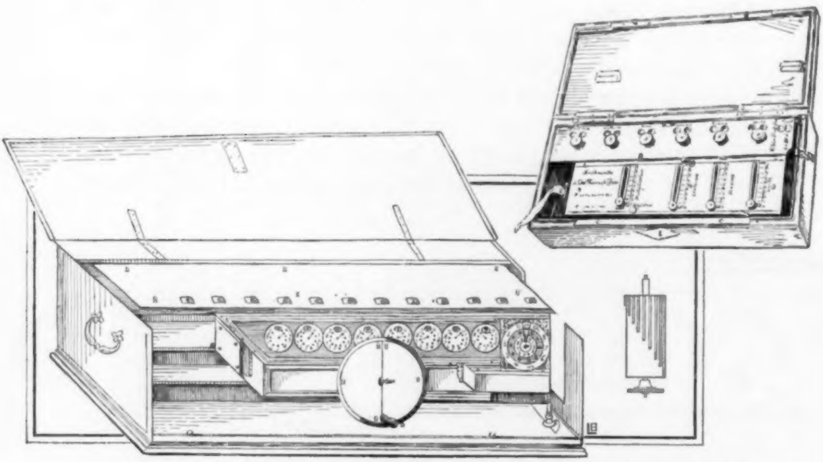


Doctor Roth's adding machine of 1841. Above is the style, or "director." This was a very satisfactory improvement on Pascal's general principle and automatically carried forward the tens.

it is generally conceded, most has been done to develop calculating machines and promote their use.

These efforts of Müller's inspired Scheutz, a printer of Stockholm, to devise a "Machine for Calculating Mathematical Tables by Differences and Printing the Results." This he began in 1834 and completed, with his son's assistance, in 1853. This was accomplished through the financial aid of the Swedish Diet, which later rewarded him generously. He was also honored by Napoleon, who placed his machine in the Imperial Observatory of Paris. Another was afterwards used by the British Government, and one, through the generosity of an American, was presented to the Dudley Observatory at Albany. These were about the size of a small grand piano.

In 1841, a physician, Doctor Roth, applied Pascal's principle to a very satisfactory adding machine that automatically carried forward the tens, and in Paris in 1858 was put on sale a "Specimen of Tables Calculated, Stereotyped and Printed by Means of a Machine."



Leibnitz' own drawing of his "Stepped Reckoner" reveals the interesting mechanism of his multiplication machine. The product was obtained by a series of rapid successive additions. At the right is a nineteenth century "Arithmometre," invented by Thomas de Colmar in 1820. The machinery was put in motion by a spring actuated by a silk ribbon. In honor of the 100th anniversary of the perfection of this machine an exposition was held in France. All modern machines are developments of this type.

The first really practical machine, however, was that of Charles Xavier Thomas, financier and honorary director of an insurance company of Colmar. In his "Arithmometre" of 1820—commonly called the Thomas de Colmar—Leibnitz' theory of the "stepped reckoner" was practically realized. It was well designed and sturdily constructed, and is the prototype of a large group of modern machines. It was improved upon by his son and others—among them workmen whom Thomas had encouraged. This machine in its own time was awarded the Grand Gold Medal of the "Societe d'Encourage-

ment pour l'Industrie Nationale" of France, and one hundred years later the same society honored it with a commemorative exposition of calculating machines, at which the original "Arithmometre" was shown and also the modern ones,—improvements, but of the same general principle.

A French writer of 1878, complaining of the time wasted in moving the index buttons of the "Arithmometre," declared that only when it would be possible to press the keys with the fingers without displacing them would the success and general employment of the calculating machine be assured.

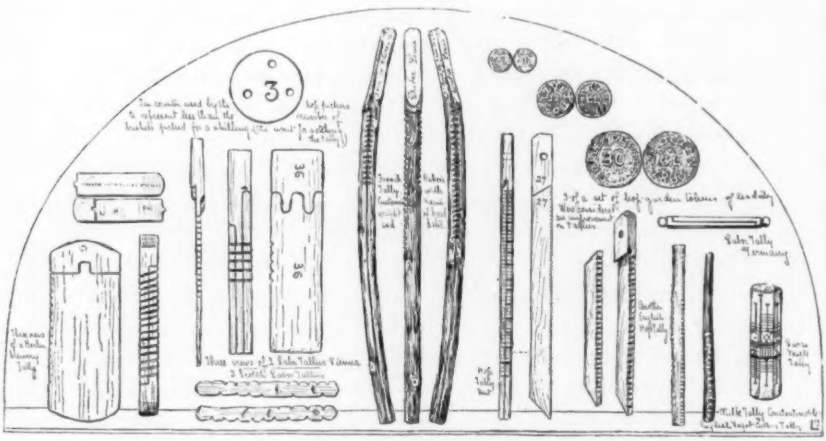
Among other machines exhibited was the first one to multiply directly. Léon Bollée—like Pascal, a boy inventor to help his father—produced this machine when he was eighteen, in 1888. His father was a bell-founder of Mans. He was obliged to employ complicated calculations to determine the model of bells. Young Bollée invented a number of very original machines, but early gave up work on them to take an active part in the development of automobiles and aviation. Bollée's calculating plates are found to be hand worked or electrically operated in the Apeiger "Millionaire," which also was exhibited.

Torres Y. Quevedo, of the Royal Academy of Spain, inventor of a machine to solve equations, showed the first machine in France that could automatically perform the four fundamental operations of arithmetic and write down the results. This machine was of the "Arithmometre" type, and wrote by means of an ordinary typewriter electrically operated.

"Undoubtedly," as it was said early in 1822, "in the midst of the tumult of affairs, it is of advantage to have an instrument which nothing can trouble nor disturb, that noise and bustle do not fret, and which readily gives the desired numerical results." Another writer of 1881 declares that "Error multiplies in the head and in the copyist's hands, and so," he adds, "should be counted among the benefactors of humanity those who consecrate their time and fortune to creating and popularizing calculating machines."

III. Tallies, Tellers and Accounting Machines

The lowly *bille* of wood, when cut, became the tally (taking its name from the French *taillé* for cut)—the clumsy bookkeeping machine of the kings of England, and served from the Norman conquest down to the nineteenth century, when they were ordered burned. October 16, 1834, was the date set for their destruction, but it was no ordinary fire that closed this chapter of English accountancy. It was a regal funeral pyre, for with the ancient tallies went both Houses of Parliament. As Sir William Anson, the English jurist, succinctly expressed it: "Orders were given to destroy the tallies. They

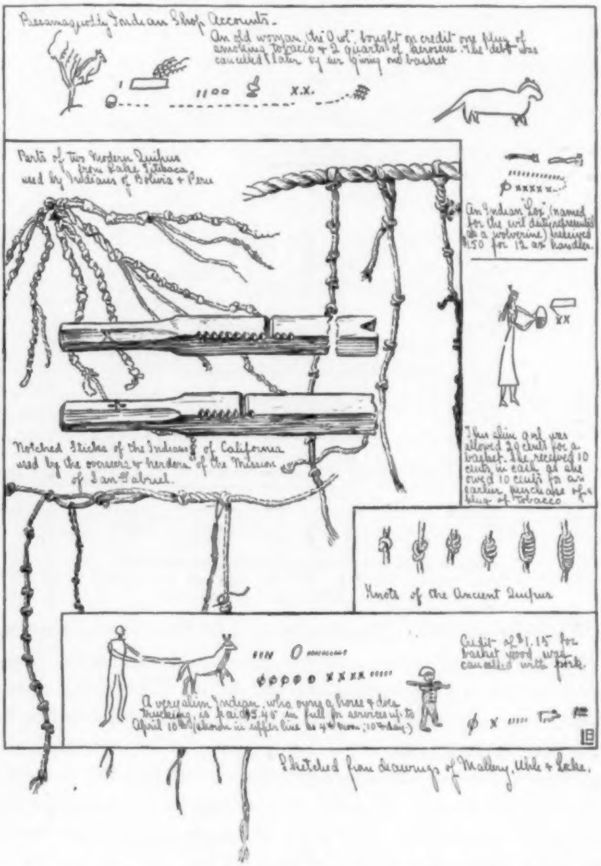


Tallies used in European countries in comparatively recent times.

were used as fuel in the stoves which warmed the Houses of Parliament; they overheated the flues and burned down the Houses."

Their use had continued long after modern methods were introduced, and Dickens accuses the Exchequer of keeping accounts "much as Robinson Crusoe kept his calendar on the desert island," and further claims that when these medieval booking machines were destroyed they should have been given for firewood to the miserably poor people of the neighborhood, but instead "They had never been useful, and official routine

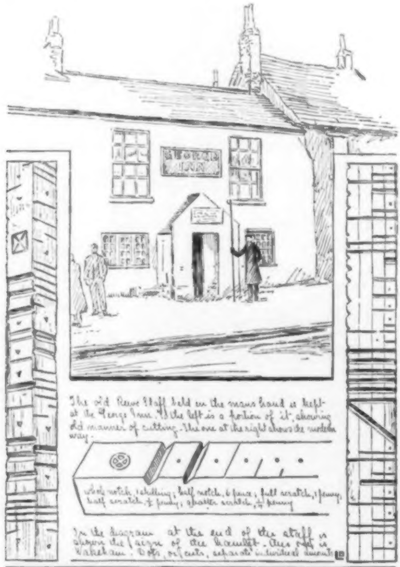
required that they never should be." Nevertheless, they had served their purpose along with the Rolls of Accounts, of which they were a part, just as other tallies, often crude bits of tree-branches or knotted strings, had served, throughout the ages, the various peoples of the world.



The Quipus and Tally Stick, as used by the Indians of North and South America.

The Incas of Ancient Peru, in their high state of civilization, used their knotted quipus to add and multiply by, and kept all records of tribute from the various villages on the

strings, separating the accounts by grains of maize or by small stones. Various colors were employed—yellow for gold, white for silver, and red to represent the soldiers. According to the Spaniards who first visited Peru, these calculations were made with great rapidity and accuracy.



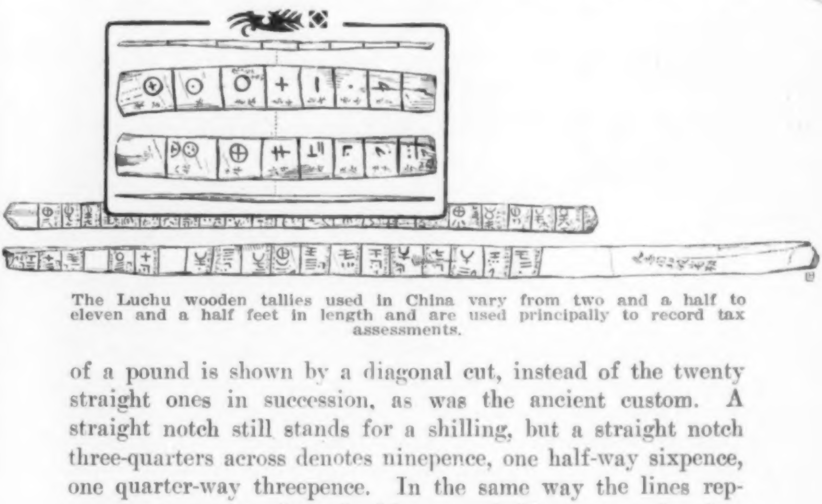
The Reeve Staff is still in use on the Isle of Portland, off the Dorset coast.

A Frenchman tells amusingly of his first experience with this type of accounting machine, while trying a case in Bengal: "I well remember my astonishment when I ordered them to produce their accounts. The Sonthal produced from his back hair, where it had been kept, I suppose, for ornament, a dirty bit of knotted grass string and threw it on the table, requesting the court to count that, as it had gotten too long for him. Each knot represented a rupee; a longer space between two knots represented the lapse of a year."

The hogs, pigs, and pieces of sandalwood for which the Hawaiians of the first part of the nineteenth century were taxed, were recorded in similar manner by the tax-gatherers of the island. A long rope was divided to represent the various districts of the island. Knotted strings are still popular

among the Indians of South America, and similar tallies are yet used in Brittany and in other parts of France, and in Scotland by the bakers. Not so long ago they were in service in Halifax, chiefly among the milkmen.

On the Isle of Portland, off the Dorset coast, old customs still prevail. The King of England, as Lord of the Manor, collects his rents through the Reeve, who records his accounts on a Saxon Staff. Reeve, or more anciently Reive, comes from the Anglo-Saxon "gerefa," a steward, who serves for one year, and only once in his or her lifetime. Both men and women serve as reeves, and the office is filled in succession by the tenant paying the highest rents. The court now meets semi-annually at the George Inn, built in the early eighteenth century, when the Reeve renders his accounting. The rent

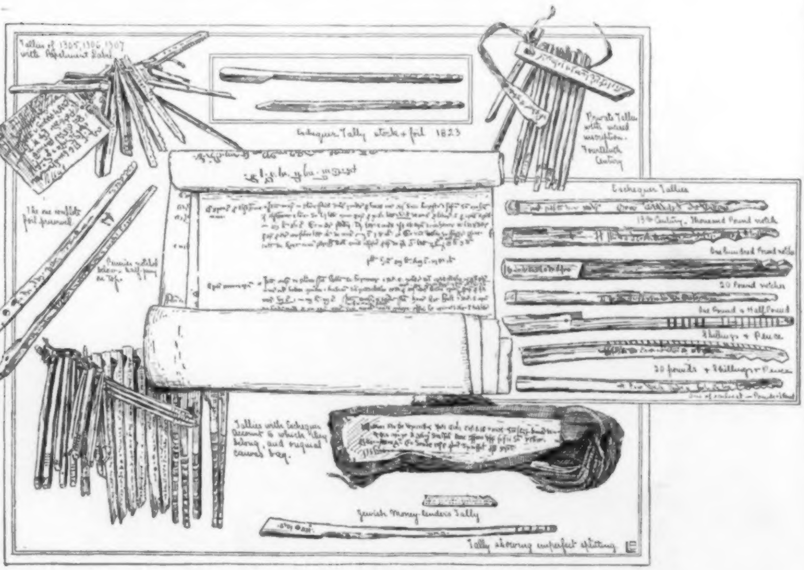


The Luchu wooden tallies used in China vary from two and a half to eleven and a half feet in length and are used principally to record tax assessments.

of a pound is shown by a diagonal cut, instead of the twenty straight ones in succession, as was the ancient custom. A straight notch still stands for a shilling, but a straight notch three-quarters across denotes ninepence, one half-way sixpence, one quarter-way threepence. In the same way the lines represent one penny, three farthings, one-half penny, and a farthing. The correct length is regulated by three faint lines drawn the length of the staff.

Until late in the 19th century tallies were much employed in the rural districts of Luchu, China, especially as records of matters referring to the assessment of taxes, both in money and kind, each item being inscribed on the tally with charcoal or any other convenient material. The symbols inscribed on the tallies are numerals, and signs are used for people's names.

The symbols varied in villages less than twenty miles apart—each village living its own isolated life.



Some of the Exchequer tallies which escaped destruction in the fire of 1834. They were found at Westminster in 1910, and are now exhibited at the Public Record Office.

With the need for higher notation came improvements upon these accounting methods, but we still use their terms. We still "present our bills," but we do not "accept" them unless we are satisfied that they "tally" with what we think we owe, which may not be as indisputable evidence as when we accepted the "bille" whose notches agreed with our half of the tally. The two parts of the tally were also called the stock ("stipes") and the foil ("folium"), and up to about a hundred years ago, if you lent money to the Bank of England, the Bank held the foil while you received the stock, thereby holding "bank stock" of the amount notched on the tally. Our checks come from the Exchequer, with its checkerboard cloth upon which counters were used for reckoning, while the "tallier," or cutter of the tallies of the Exchequer, later became its teller. There were four of these, each receiving three pence a day when the

Exchequer was at London. Their duties are described by Madox, writing in 1708: "The Sum of Money which it bore was cut in Notches in the Wood by the Cutter of the Tallies, and likewise written upon two Sides of it by the Writer of the Tallies. The Tally was cleft in the Middle, by the Deputy Chamberlains, with a Knife and Mallet, through the Shaft and the Notches; whereby it made two Halves, each Half having a Superscription and a Half Part of the Notch or Notches. . . . A day later, at the earliest, the payer received his half of the tally."

The procedure is quite different today, and is well illustrated by the methods used by the Bank for Savings and many other banks in New York and elsewhere. The modern "writer of the tallies" is the electrically-operated posting machine, which records the deposit in pass-book and on audit sheet and dates and identifies each entry by account number and teller's symbol, all within one minute.

Developmental Recitation in General Science*

By Walter R. Kukets.

In the teaching of general science, it sometimes happens that a pupil will ask, at the beginning of the class period, a question which will upset, or at least change, the regular plans of the teacher for that particular recitation. Especially is it true, if this question is of a kind which may lead to fruitful results if followed out to its final conclusion. Such a question was asked, and it led to the development of the following recitation. Consequently, this recitation differs from the ordinary recitation in that the pupils had made no previous preparation and it was based entirely on their experience.

At the beginning of the recitation period, one of the pupils asked the following question: "Has the moon an orbit around the orbit of the earth or around the earth itself?" It was evident to the teacher that by working with this question it would be possible to turn out enough subordinate questions and points to meet the following general science aims:

A. To show the relationship between the sun, moon, and the earth.

* From Educational Research Circular, No. 47, Univ. of Illinois Bulletin.

B. To show the position that these three bodies must occupy in the universe in order to have an eclipse of the sun, and of the moon.

C. To explain the following related phenomena:
   a. The seasons, night and day.
   b. Circumference of the earth's orbit.

The teacher suggested to the members of the class that they write on the blackboard some of the things they knew concerning the sun, moon, and the earth. The following information was furnished by the pupils, representing the sum total of their knowledge of the subject matter:

1. Most of the pupils had seen an eclipse of the sun.
2. Few had seen an eclipse of the moon.
3. All were familiar with night and day, and the seasons.
4. One pupil had heard of gravity.
5. Three pupils stated that there was another force which held the universe together, and that this force was called gravitation.
6. All pupils stated that an ordinary year contained three hundred and sixty-five days.
7. Two pupils stated that every four years there was a year which had three hundred and sixty-six days, and that this year was called leap-year.
8. Some stated that the sun and the moon had some influence on the tides.
9. One pupil stated that the circumference of the earth was twenty-five thousand miles.
10. One pupil stated the earth moved on its orbit, and that the turning of the earth and the inclination of the earth's axis produced our days and nights and seasons.

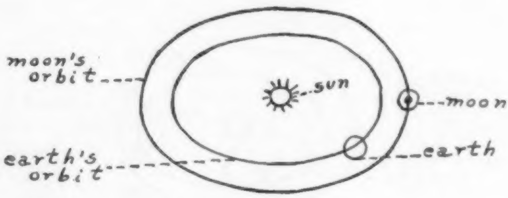
Using these ten statements as a basis for future developments, we turned our attention to the answering of the above mentioned question. We had to derive some definite statements regarding the location in space of the three bodies. "What must be the relation between the three bodies, class?" One pupil stated that the earth had an orbit and that it traveled along this orbit. He volunteered to make a diagram on the blackboard, showing this relationship.

His diagram showed the orbit of the earth; around this orbit there was another orbit larger than that of the earth's,

along which the moon was supposed to travel. The sun was in the center of the diagram.

This diagram gave us some idea of the relative locations of the three bodies in space, and the only thing ke had to do was to discover some means for determining whether or not this diagram represented the true state of affairs. The following question was asked: "Would it be possible to have an eclipse of the moon if this diagram represented the true conditions?" One pupil stated that in order to have an eclipse of the moon something must come in between the moon and the sun. "What must this something be?" One pupil suggested that since moonlight was reflected sunlight, the only thing that could come in would be the earth. All pupils saw that if the earth came in between the sun and the moon, the

DIAGRAM I.



earth's shadow would be cast on the face of the moon, and would cause an eclipse.

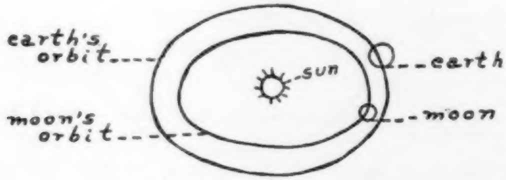
This would account for the eclipse of the moon. "But what about the eclipse of the sun?" Here we had to derive another general statement and prove it, in order to make it applicable as a criterion for our recitation. Three pupils stated as follows: "Well, now, if the earth had to come in between the sun and the moon in order to have an eclipse of the moon, something must come in between the sun and the earth, in order to have an eclipse of the sun." "Can the moon come in?" asked the instructor. It was plainly to be seen that if the moon came in between the sun and the earth that a section of the sun's surface would be shut off, and there would result an eclipse of the sun. In this manner we derived the following criteria for judging whether or not the diagram made by the pupil was correct:

A. An eclipse of the moon will result when the earth somes in between the moon and the sun and casts its shadow on the moon. This eclipse will take place only when they are all in a straight line.

B. An eclipse of the sun will result when the moon comes in between the sun and earth, and shuts off a part of the sun's surface from view. This will take place only when they are all in a straight line.

We applied the two criteria to Diagram I, and found that the earth will come in between the sun and the moon, and that if the three bodies are in a straight line, an eclipse of the moon will result. Next we tried to find out whether or not there could be an eclipse of the sun. On examining the diagram we found that the moon could never come in between the sun and the earth. It was evident that the diagram could not satisfy the criterion for the eclipse of the sun.

DIAGRAM II.



The next question was: "What rearrangement can we make in this diagram, so that the moon will come in between the other two bodies and cause an eclipse of the sun?" One pupil stated that the orbit of the moon should be inside of the earth's orbit. This pupil made a diagram on the blackboard expressing his idea of the relationship between the three bodies. His diagram is essentially the same as Diagram I, except that the orbit of the moon is inside of the earth's orbit. (By inside is meant the side nearest to the sun.)

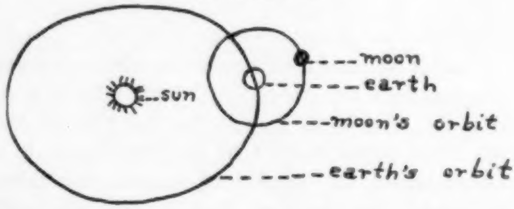
Once more we applied criterion A, this time to the second diagram, to see whether or not the earth will come in between the sun and the moon and cause an eclipse of the moon. On examining the diagram we found that the earth would never come in betwee nthe other two bodies and cause an eclipse of the moon.

Next we tried to find out whether or not the moon would

come in between the earth and the sun, and cause an eclipse of the sun. On examining the diagram we found that the moon would come in between the earth and the sun, as its orbit was inside that of the earth's orbit. The second diagram would meet the criterion for the eclipse of the sun, but would not meet the criterion for the eclipse of the moon. Consequently we had to abandon this diagram and look for something better,—one which would satisfy both of the criteria.

The teacher asked the following question: "How can we combine these two diagrams in such a way as to meet both of the criteria?" For a while there was thoughtful silence; then one pupil stated that the moon's orbit was not around the orbit of the earth, but around the earth itself. This pupil made a new diagram on the blackboard. He located the sun in the center of the diagram, the orbit of the earth around the sun, and the orbit of the moon around the earth itself, instead of around the orbit of the earth as in the two previous diagrams. We analyzed this new diagram to see if it would meet the two criteria previously worked out.

DIAGRAM III.



We found that the earth would come in between the sun and the moon, and cause an eclipse of the moon. This met one of the criteria. Next we tried to see whether or not the moon would come in between the earth and the sun, and cause an eclipse of the sun. We found that it would. This satisfied the second criterion. Of the three diagrams this was the only one that would meet the given conditions.

We had developed a diagram showing the location, arrangement, and relation to one another of the three bodies. We also had developed an explanation for the eclipse of the moon and the sun, not from a diagram as worked out by someone else, but by combining our common experiences and common sense.

There remained some other questions to be answered. One of these questions was: "What must be the circumference of the earth's orbit?" We found in Diagram III that the earth's orbit was around the sun. One pupil asked: "What happens when the earth has made a complete journey around the sun on its orbit?" One pupil stated that when the earth makes a complete trip around its orbit that it means the completion of a year. Reversing the question, it would mean that it took the earth exactly a year to make a complete journey around the sun. One pupil stated that it was not true, as some years had three hundred and sixty-five days, and that every fourth year had three hundred and sixty-six days. There was silence for a moment, then one pupil stated that it took more than three hundred and sixty-five days for the earth to make a complete journey around its orbit. One pupil stated that perhaps it took three hundred and sixty-five days and six hours for the earth to make a complete round trip. These six hours were not counted until the fourth year, when a whole day was added to the year. This sounded reasonable, and so we accepted that as a final statement. Still the question asked at the beginning of the paragraph remained to be answered. One pupil suggested that if we knew at what rate the earth traveled on its orbit we could calculate the circumference of the orbit. The teacher had to supply them with the necessary information that the earth traveled at the rate of 18.5 miles per second. One pupil stated that we must know, in addition to the rate of travel, the number of seconds that there are in any given year. We assumed that it took the earth three hundred and sixty-five days and six hours to make a complete journey around its orbit. Using that data, we found that the circumference of the earth's orbit was about 600,000,000 miles.

In addition to basing the recitation on the experience of the pupils, there was plenty of opportunity given for them to express themselves on any phase of the subject.

At the the end of the period each pupil felt that he or she had contributed something toward the completion of the lesson. The teacher, during the whole recitation, led the class to discover the right answer by suggestions or criticisms of their reasoning.

Pennsylvania Science Teachers Organize

More effective organization of science teachers of Pennsylvania was definitely gotten under way at meetings held in Harrisburg, December 29 and 30, in connection with the convention of the Pennsylvania State Education Association. It was decided that the science organization would identify itself, for the present, as the Science Section of the P. S. E. A., holding a central convention jointly with the annual meeting of the State teachers' association, and holding zone meetings in conjunction with various district conventions of that association, throughout each year.

The first zone meeting of science teachers this year will be at Bloomsburg, Pa., on Saturday morning, March 12, at which time Prof. W. L. Eikenberry, Science Department, East Stroudsburg State Normal School, is scheduled to lead the discussion on topics of vital interest to science teachers. This meeting is in connection with the northeastern district convention of the P. S. E. A.

There will be science teachers' meetings also in connection with district conventions at York, Pa., March 18 and 19; at Pittsburg, Pa., March 23; and at Philadelphia, March 30 to April 2. The western district science teachers are well organized, as the Langley Association of Science Teachers. It is planned to make the activities of this live organization a model for state-wide gatherings of science teachers. In order to attempt a greater unity of effort, the State science teachers' convention at Harrisburg, December last, elected as State President, Mr. C. A. Gorgas of Peabody High School, Pittsburgh, Pa., who is likewise president of the Langley Association. The State secretary is Mr. Clarence E. Baer, New Castle Senior High School, former president of the Langley Association and an active worker likewise in the move for state-wide organization.

The next central convention of State science teachers will be held in connection with the P. S. E. A. annual meeting at Lancaster, Pa., December next.

There was an overflow meeting at Harrisburg at the central meeting of science teachers, December last. The addresses were given by Dr. J. A. Foberg, State director of mathematics

and science of the Department of Public Instruction of Pennsylvania, on "Science in the Junior High School," and by Dr. Otis W. Caldwell, director of the Lincoln School of New York City, on "The Tendencies in Science Teaching." L. Paul Miller, Central High School, Scranton, Pa., presided. W. A. McCune, William Penn High School, Harrisburg, Pa., served as vice-president, and Clarence E. Baer, New Castle Senior High School, as secretary. G. N. C. Henschen, William Penn High School, was in charge of visits to local industries. There were trips of special interest to The Metropolitan-Edison plant at Middletown, at which the powdered coal process is being installed for the operation of units of 35,000 kilowatts each, and to the Middletown Aviation Depot of the United States Army, Major Weaver in charge, at which repairs to Liberty motors and planes are being made on an extensive scale.

Prof. W. L. Eikenberry of East Stroudsburg presided at a Science dinner, during which the plans for State organization were put into operation. Among impromptu speakers, in addition to the names already mentioned, were: Dr. Gerald Wendt, dean of School of Chemistry and Physics, State College; Dr. S. C. Schmucker, West Chester; L. J. Ulmer, Lock Haven State Normal School; and John A. Hollinger, director Nature Study, Pittsburgh.

The following have been named by Mr. Gorgas to serve on a committee on state-wide organization of science teachers, whose particular function is to aid in arranging science meetings in various convention districts: Dr. Gerald Wendt, State College, chairman; Dr. Edward E. Wildmar, Philadelphia; B. B. Herr, Lancaster; L. A. Armogost, Erie; Dr. John Hollinger, Pittsburgh, and Dr. W. L. Eikenberry, East Stroudsburg.—*Reported by* L. PAUL MILLER, *Scranton.*

Graduate Training

The School of Chemistry and Physics of Penn State College has a limited number of opportunities for high-grade men to earn their way while completing their graduate training in physics or chemical engineering.

If interested, apply to G. L. Wendt, Dean, Penn State College, State College, Pennsylvania.

The New Books

Indian Designs and Symbols—Charles Frederick Whitney—55 pages—75c (in lots of 10 or more, 60c)—published by the author, Normal School, Salem, Massachusetts.

The book gives 55 pages of Indian designs accompanied by text interpreting the designs and symbols. The drawings are illustrative of: 1, Natural Phenomena; 2, Natural Features; 3, Man and Animal Life; 4, Birds and Butterflies; 5, Occupations; 6, Myth, Legend and History. This material has been found not only useful but fascinating in the study of history, geography, language, art, etc. Pupils enter readily into the spirit of the Indians and interpret the symbols at once.

How the World Rides—Florence C. Fox—81 pages—illustrated—Bulletin, 1926, No. 8—25c—Superintendent of Documents, Government Printing Office, Washington, D. C.

This pamphlet contains a series of projects on vehicular transportation for elementary schools. Geography, history, science, literature, music, and art are school subjects that have some contributions to make to this subject, "How the World Rides." The author has focused these different branches of study upon one general theme of transportation. Elementary teachers will find much to help them in this work.

Elements of Physics—Millikan, Gale and Pyle—509 pages—483 illustrations—$1.64—Ginn and Company.

The chief aim of the book, in the words of the author, is "To present elementary physics in such a way as to stimulate the pupil to do something on his own account about the hows and whys of the physical world in which he lives." This book includes the subject-matter relating to the everyday life of the pupil. The material is so arranged that a short course may be given by using the coarse print only. The recent applications of physics, and reference to the work of men who have made the history of physics, are stimulating features, while questions, problems and summaries add to the effective teaching value of the book.

The Sciences, Revised Edition—E. S. Holden—224 pages—198 illustrations—84c—Ginn and Company.

This is a science reader for young children, written in dialogue form. It will interest children, and is full of useful science knowledge about such things as the stars, planets, meterology, states of matter, the atmosphere, the steam engine, images, shadows, sound, magnets, simple applications of electricity, and chemistry. It is a very readable book in any grade from the sixth to the eighth.

Conquering the Air—Archibald Williams—315 pages—illustrated—12 half-tone plates and numerous line cuts—$2.00—Thomas Nelson and Sons.

This book should be placed on your general science reference bookshelf. It has the historical material besides the facts of present-day aviation that will be very helpful in all class discussions of air transportation. It is a readable book, suitable for junior high children. Some of the chapter titles are as follows: Fire Balloons; Gas Balloons; First Crossing the English Channel by Air; Dirigibles; First Attack on the Atlantic; Pioneers of Mechanical Flying; First Crossing of the Atlantic by Air; To New York and Back; London to Australia; First Non-stop Flight Across America, Aircraft in Polar Regions; First Flight Around the World; Life-Belts of the Air.

Hygiene—Florence L. Meredith, M.D.—719 pages—268 illustrations—$3.50—P. Blakiston's Son and Company.

This is an elementary college text and an exceptionally good one. The laboratory work suggested to accompany the textbook study is the daily life of the student. The author strives to make this a real *personal* study to add to one's store of health, and it is not just a book study of anatomy and physiology.

There are 48 chapters, separated into four groups or parts: 1. Introduction (66 pp.); 2. Anatomy and Physiology (164 pp.); 3. Pathology Conditions (71 pp.); 4. Hygiene (384 pp). The appendix gives the chemical composition of American foods, table of 100 calorie portions, and a bibliography.

King-Clark Foods Test—$1.00 per 25—World Book Co.

This is a standard measure of students' knowledge and ability in the essentials of a course in foods or cooking. It serves the several purposes of any achievement test. Its specific uses and the method of its construction and standardization are pointed out in the Manual of Directions.

Instructional Tests in Algebra, With Goals for Pupils of Varying Abilities—Raleigh Schorling, John R. Clark and Selma A. Lindell—72 pages—28 cents—World Book Company, Yonkers-on-Hudson, N. Y.

These Instructional Tests in Algebra, prepared by Doctors Schorling and Clark, make it possible for teachers of first-year algebra to utilize well-accepted principles from the psychology of drill in improving the skill of students in algebraic computation. There are 52 different practice exercises in the book, covering all the essential skills of a first-year course. Standards or goals have been set up, based upon the actual performance of large numbers of students, and these standards are given for three different levels of ability,—the bright, the average, and the backward. Teachers of algebra should find these instructional tests not only the means of increasing the proficiency of their students, but also of saving their own time and of interesting students in their own improvement.

Physiology and Biochemistry in Modern Medicine—Fifth edition—J. J. R. Macleod—1054 pages—291 illustrations and 9 plates in color—$11.00—C. V. Mosby Company, St. Louis.

This is a "guide to the application of the truths of physiology in the bedtime study of disease," but also "may be used as a textbook of physiology for students of medicine." The chapters on blood, respiration, ductless glands, and metabolism, have been rewritten to bring them up to the latest advance of knowledge. Other chapters have been revised and much new material added. There are 103 chapters in all. The book is divided into ten parts, as follows: 1. The physicochemical basis of physiological processes; 2. The blood and the lymph; 3. The neuromuscular system; 4. The special senses; 5. Circulation of the blood; 6. Respiration; 7. Digestion; 8. The excretion of urine; 9. Metabolism; 10. The endrocine organs or ductless glands.

Commercial Raw Materials—Charles R. Toothaker—308 pages—57 illustrations—$2.00—Ginn and Company.

This book is not only interesting reading to those who like to know the sources of things, but extremely valuable as a school reference book or a text in commercial geography. It covers foods, beverages, medicines, oils, fibers, skins, woods, gums, metals, and non-metallic elements.

Embryo of the Pig—Bradley M. Patten—323 pages—168 illustrations—$3.50—P. Blakiston's Son and Co.

Mammalian development is easily shown in laboratory by means of pig embryos. The developmental processes are emphasized in this book. The book will be found a valuable text and an invaluable assistant to go along with the laboratory work. The line and wash drawings are excellent, and there are two full pages in color.

Palladin's Plant Physiology—Revised by B. E. Livingston—360 pages—174 illustrations—$4.00—P. Blakiston's Son and Co.

This revised edition of a standard work will be welcomed by all biology teachers and workers. General Science teachers will get much help from it. The book is divided into two parts: 1. Physiology of nutrition; 2. Physiology of growth and configuration.

World Geography. II. The Old World—F. M. McMurray and A. E. Parkins—323 pages—289 illustrations and maps—The Macmillan Company.

This is a companion volume to Book I, The New World, which appeared a short time ago. The conditions in parts of the Old World cause constant revision of our geographies. In this book we have the latest word regarding those countries which are in the state of flux. The maps also are thoroughly up to date. Helpful questions direct the study and thinking of the child.

A Manual in Preliminary Dietetics—Maude A. Perry—146 pages—C. V. Mosby Company, St. Louis.

This book contains a series of lessons as given in a preliminary dietetics course for nurses. The material covers fifteen lessons of three hours each. The topics discussed in each lesson are: 1. Feeding the sick, nutrition, beverages; 2. Foods, principles, sanitation, methods of cooking, demonstrations; 3. Milk; 4. Eggs; 5. Carbohydrates, cereals; 6. Carbohydrates, vegetables; 7. Carbohydrates, fruits; 8. Meat, fish, poultry; 9. Bread; 10 Frozen desserts; 11. Food requirements, menu making; 12. Meal planning, light and liquid diets; 13. Diet for infants, food for the aged; 14. Food values, charts and tables, computations; 15. General review, additional recipes, list of suggestive equipment.

Hospital Housekeeping and Sanitation—Nora P. Hurst—155 pages—$1.25—C. V. Mosby Company, St. Louis.

This book was written primarily for hospital training schools, but will be useful to general housekeepers, school economics classes, and in public schools. The chapter headings give the key to the contents of the book: Cleaning and polishing interior furnishings; Equipment and arrangement; Heating and ventilating; Lighting and plumbing; Disposal of garbage; Household pests; Laundry; Care of linen; The clothes room; Hospital supplies.

Living Things—A. G. Clement—488 pages—illustrated—Iroquois Publishing Company.

This book gives an elementary treatment of the functions of living things, namely: functions of relation, of nutrition, and of reproduction. It is treated in five parts: 1. Principles; 2. Applications of principles to animals; 3. Application of principles to man; 4. Application of principles to plants; 5. Application of principles to human interests.

Supplementary Science Sheets for Pupils

Besides our regular standard science magazines, there are now three science sheets offered at prices which should make them available to each member of the class. These all give valuable supplementary science material.

Science News Letter. Weekly. 21st and B Streets, Washington, D. C. This gives interesting information from all fields of science. Articles are classified as to the field of science. Here you find up-to-the-minute science. In lots of 10, the cost is 6 cts. a copy.

Current Science. Weekly. 1123 Broadway, New York City. We are glad to welcome this newest of our classroom helps. This unique little science folder comes perforated, ready for binding in covers which are furnished free by the publishers, and, as its name implies, it brings you an account of the outstanding current science events of the day and other science items of interest. The cost is about 2 cents a copy in lots of 30 copies.

Science Classroom. Monthly. This has demonstrations and suggestions helpful to teachers, and references to articles in Popular Science Monthly for pupil use. Much help is given in the method of using magazine articles in the classroom. The cost is 25 cents a year (10 copies).

Science Articles in Current Periodicals

[These classified articles should make valuable supplementary reading for the pupils. In some cases the material is in such form that it would be too difficult for many of the pupils to abstract the matter for themselves. In such cases the article may be read by the teacher and passed on to the pupil in class. Such articles are starred.

AIRPLANES

*Exploring the Earth's Stratosphere. Nat. Geog, Mag., 50:755, Dec. 1926.

Oblique Aerial Surveying in Canada. Geog. Rev., 16:568, Oct. 1926.

Progress in Air Transportation. Coml. Amer., 23:5:17, Nov. 1926.

ASTRONOMY

The Romantic Search for "Pocket" Planets. Sci. Amer., 136:1:9, Jan., 1927.

Children of the Sun. Sci. Amer., 136:6, Jan. 1927.

Marvels of Interplanetary Space. Sci. and Inv., 14:987, Mar. 1927.

To the Moon at Seven Miles a Second. Pop. Sci. Mon., 110:2:29, Feb. 1927.

A Twenty-five Foot "Eye." Sci. Amer., 135:174, Sept. 1926.

BRAIN

The Meaning of the Brain. Sci. Amer., 136:1:13, Jan. 1927.

BRICK

Brick Through the Ages. Gar. and Home Builder. 24:357, Jan., 1927.

Brick in the Garden Picture. Gar. and Home Builder, 44:362, Jan. 1927.

Brick as a Fireproof Material. Gar. and Home Builder, 44:386, Jan. 1927.

Lengthening the Life of Brick. Gar. and Home Builder, 44:390, Jan. 1927.

CHEMICAL ELEMENTS
Building Blocks of the Universe. Sci. Amer., 136:87, Feb. 1927.

CHINA
Links Between Ancient China and the West. Geog. Rev., 16:614, Oct. 1926.

CITRUS INDUSTRY
Chemistry of the Citrus Industry in California. Jo. Chem. Ed., 3:1117, Oct. 1926.

COAL
Liquid Coal Sooner or Later. Lit. Dig., 92:2:22, Jan. 8, 1927.
Crystals of Fire. Pop. Sci. Mon., 110:3:11, Mar. 1927.

DIVING
Man's New Conquest of the Deep. Pop. Sci. Mon., 110:2:30, Feb. 1927.

DYESTUFFS
The Growth of the Dyestuffs Industry. Jo. Chem. Ed., 3:973, 1926.
The Dye Industry in America Jo. Chem. Ed., 3:1128, Oct. 1926.

FOODS
Two Decades of Food Law Enforcement. Amer. Food Jo., 21:561, Dec. 1926.
History of United States Food Laws. Amer. Food Jo., 21:564, Dec. 1926.

FUR
Collection of Furs. Jo. Home Econ., 18:691, Dec. 1926.
Fur Dressing. Jo. Home Econ., 19:16, Jan. 1927.
Fur Dyeing. Jo. Home Econ., 19:75, Feb. 1927.

GARDENS
When You Plant Your Florida Garden. Gar. and Home Builder, 44:379, Jan. 1927.
Carrying the Garden into the Sun Room. Gar. and Home Builder, 44:461, Feb. 1927.
Vegetable Gardening on a Time Schedule Basis. Gar. and Home Builder, 44:451, Feb. 1927.

GASOLINE
Thrills in the Hunt for Black Gold. Pop. Mech., 47:393, March, 1927.

HEALTH
Light and Health. Jo. Fran. Inst., 203:1-10, Jan. 1927.
Modern Sinus Trouble. Hygeia, 5:3, Jan. 1927.
Relation of Animal Diseases to Public Health. The Nation's Health, 9:9, Jan. 1927.
"Health Glass" for Our Windows. Pop. Sci. Mon., 116:2:16, Feb. 1927.

LIGHTING
*Twenty Years of Lighting Progress. Trans. Ill. Eng. Soc., 21: 1078-1152, Dec. 1926.

MILK
Story of Milk. Coml. Amer., 23:6:17, Dec. 1926.

PHOTOGRAPHY
*Practical Kinematography. Photo Era, 58:73, Feb. 1927.
Convenient Photo Finishing. Photo Era, 58:67, Feb. 1927.
How Shall I Set the Shutter. Photo Era, 58:81, Feb. 1927.

PRIESTLEY
Priestley's Life in Northumberland, and other articles. Jo. Chem. Ed., 4:145-199, Feb. 1927.

PRUNING

Pruning Fruit Trees for Fruit. Gar. and Home Builder, 44:471, Feb. 1927.

RADIO

A New Alliance—Phonograph and Radio. Lit. Dig., 92:8:21, Feb. 1927.

"Hello London." Phone Spans Atlantic. Pop. Mech., 47:353. Mar. 1927.

Hope of Seeing by Radio Brought Nearer Fact. Pop. Mech., 47:359, Mar. 1927.

Radio Along the Airways. Sci. Amer., 136:32, Jan. 1927.

Radio's Silver Screen: Wireless Vision. Sci. Amer., 136:106, Feb. 1927.

What is the Best Loud Speaker, and Why? Radio News, 8:1106, March, 1927.

A, B and C Battery Eliminators. Sci. and Inv., 14:1034, March, 1927.

*SCIENCE TEACHING

Method of Teaching Oxidation and Reduction Reactions. Jo. Chem. Ed., 4:223, Feb. 1927.

Inorganic Chemistry for the Home Economics Classes. Jo. Chem. Ed., 3:1144, Oct. 1926.

Project Method Applied to Nature Study. Jo. Ed. Meth., 6:216, Jan. 1927.

Method of Increasing Interest and Providing for Individual Differences in High School Science Laboratory. School Rev., 34:782, Dec. 1926.

Method of Teaching Chemistry. School Rev., 34:591, Oct. 1926.

Practical School Health Program. Jo. Ed. Meth., 6:103, Nov. 1926.

SCOUTS

Cooking in the Snow. Food and Health Ed., 22:2, Jan. 1927.

SOUND

Seeing Sound. Lit. Dig., 92:6:23, Feb. 5, 1927.

TELEVISION

Television by New French System. Sci. and Inv., 14:988, Mar. 1927.

WATER SUPPLY

Sewage and the Water Supply. Hygeia, 5:90, Feb. 1927.

Origin and Growth of Public Water Supply. Part II. Amer. City, 36:49, Jan. 1927.

WELDING

Terrific Temperatures in Welding. Lit. Dig., 92:6:25, Feb. 5, 1927.

WHAT TO MAKE

Paper Steam Engine. Sci. and Inv., 14:1028, Mar. 1927.
Miniature Volcano. Sci. and Inv., 14:1028, Mar. 1927.
Home-Made Balance Weights. Sci. and Inv., 14:1023, Mar. 1927.
Simple Steam Engine. Sci. and Inv., 14:1916, Feb. 1927.
Parchment Paper. Sci. and Inv., 14:1916, Feb. 1927.
A Simple Electric Furnace. Sci. and Inv., 14:919, Feb. 1927.
An Atomizer. Sci. and Inv., 14:922, Feb. 1927.
A Mystery (Camphor) Boat. Sci. and Inv., 14:922, Feb. 1927.
How to File Door Keys. Pop. Sci. Mon., 110:2:109, Feb. 1927.

Magazine List

American City. 443 Fourth Ave., New York City. Monthly. $4.00 a year, 50c a copy. The science problems of city and rural communities are treated in numerous articles, well illustrated. A valuable student and teacher reference.

The American Food Journal. 468 Fourth Ave., New York City. Monthly. $3.00 a year, 25c a copy. Articles on food manufacture, food legislation, and experiments in nutrition.

Commercial America. Philadelphia Commercial Museum, Philadelphia, Pa. $2.00 a year. Ill. Commercial production. New inventions. Will interest commercial geography and science teachers.

The Educational Screen. 5 South Wabash Avenue, Chicago. Monthly. 20c a copy, $1.50 a year; with "1000 and One Films," $1.75 a year. Discusses the use of motion pictures, slides, and other visual aids in our schools; gives brief descriptions of educational films, and lists of theatrical films which are suitable for children. The journal is entirely educational, having no commercial affiliations.

Garden and Home Builder. Garden City, N. Y. Monthly. 35c a copy, $3.00 a year. Ill. Helpful to amateur gardeners, home makers, teachers and pupils.

General Science Quarterly. Salem, Mass. Quarterly. 40c a copy. 1.50 a year. The only journal published devoted alone to science in the elementary and secondary schools. It tells what schools are doing in science, gives lesson plans, demonstrations, and an extensive bibliography of usable articles in current periodicals.

The Geographical Review. Broadway at 156th Street, New York. Quarterly. $1.25 a copy, $5.00 a year. Devoted to scientific geography. Original maps and piectures. One department contains condensed items of topics of current interest.

The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Hygeia. 535 North Dearborn St., Chicago. Monthly. 25c a copy, $3.00 a year. Popular articles on individual and community health. A valuable supplement to classroom work in hygiene.

Industrial and Engineering Chemistry. Box 505, Washington, D. C. Monthly. 75c a copy, $7.50 a year. A technical journal which contains much material which teachers can use.

Journal of Chemical Education. Kodak Park, Rochester, N. Y. Monthly. $2.00 a year. Promotes chemical education; primarily a journal for the chemistry teacher. Digests of activities of chemical associations.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 617 Mills Bldg., 700 17th Street N. W., Washington, D. C. Monthly. 25c a copy, $2.50 a year. For teachers.

The Literary Digest. 354 Fourth Ave., New York. Weekly. 10c a copy $4.00 a year. Has a department, "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

National Geographic Magazine. Washington, D. C. Monthly. 50c a copy, $3.50 a year. Best monthly journal for high-grade pictures. Articles are of interest to general readers, pupils and teachers, as well as to geographers.

The Nation's Health. 22 East Ontario Street, Chicago, Ill. Monthly. $3.00 a year, 25c a copy. An illustrated magazine devoted to community, industrial and institutional health problems. Very helpful to the science and hygiene teacher.

Popular Mechanics Magazine. Chicago. Monthly. 25c a copy, $3.00 a year. Short science items and articles, well illustrated. Appeals strongly to elementary pupils. Suggests many construction problems.

Popular Science Monthly. 225 West 39th Street, New York City. Monthly. $2.50 a year, 25c a copy. A review in text and pictures of the news of science and invention, presented in a humanistic and inspirational way. Used as a supplement to text-books in many high schools. Valuable to science pupils and teachers.

Radio News. 53 Park Place, New York City. 25c a copy, $2.50 per year. Monthly. A practical periodical for all who are interested in radio. Gives radio progress, new hook-ups, and gives much help to one who may wish to construct his own set.

Safety Engineering. 119 Nassau St., New York. Monthly. $3.00 a year, 25c a copy. A journal devoted to conservation of life and property, and contains much material helpful in science classes.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Science Classroom. Issued by "Popular Science Monthly," October to June. 25c a year. A valuable teacher's aid, giving lesson plans, experiments, and many reference suggestions for secodary science teachers.

Scientific American. Woolworth Building, New York. Monthly. 35c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated. Particularly valuable to high school science pupils and teachers.

Science and Invention. 53 Park Place New York City. Monthly. 25c per copy, $2.50 a year. Ill. Popular articles on astronomy, physics, photography, radio-activity, medicine, and, in fact, science in general.

Scientific Monthly. Garrison, N. Y. 50c a copy, $5.00 a year. Articles, as a rule, are more along lines of pure science. Much of value to teachers. Articles can be read to advantage by many pupils.

Science News-Letter. Science Service, 1115 Connecticut Ave., Washington, D. C. Weekly. 10c a copy $5.00 a year. Gives a valuable current summary of the progress of science, in a form usable in science classes.

Transactions of the Illuminating Engineering Society. 29 West 39th Street, New York. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.